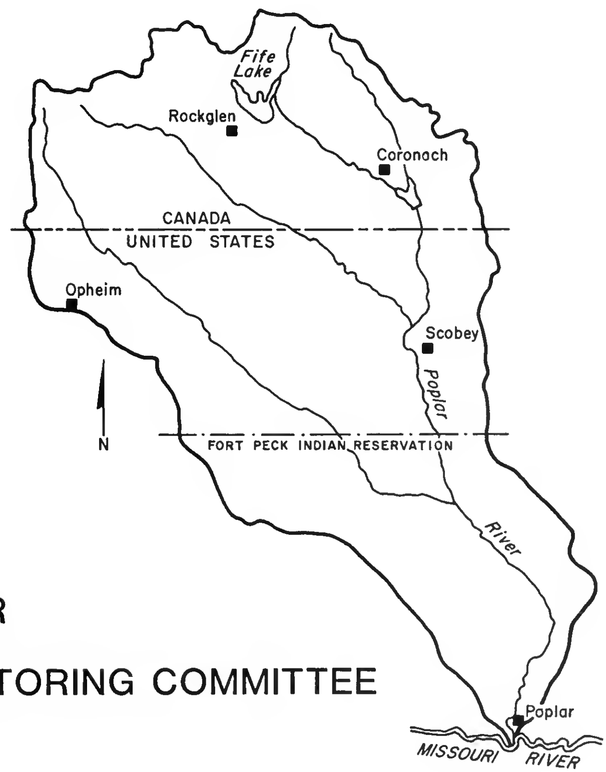
1990 ANNUAL REPORT

to the

GOVERNMENTS OF CANADA, UNITED STATES, SASKATCHEWAN AND MONTANA



by the

POPLAR RIVER BILATERAL MONITORING COMMITTEE

COVERING CALENDAR YEARS 1981-90

December 1991

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POPLAR RIVER BILATERAL MONITORING COMMITTEE

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POPLAR RIVER BILATERAL MONITORING COMMITTEE

Department of State
Washington, D.C., United States

Department of External Affairs
Ottawa, Ontario, Canada

Governor's Office
State of Montana
Helena, Montana, United States

Saskatchewan Environment and Public Safety
Regina, Saskatchewan, Canada

Ladies and Gentlemen:

During 1990, the Poplar River Bilateral Monitoring Committee continued to fulfill the responsibilities assigned by the governments under the Poplar River Cooperative Monitoring Arrangement dated September 23, 1980. Water quantity, water quality, and air quality relevant to the International Boundary were monitored in accordance with the 1990 Technical Monitoring Schedule. The monitoring data were exchanged on a quarterly basis.

This annual report is the tenth of a series covering the period 1981-90. The report summarizes environmental conditions in the basin during 1981-90 and discusses Committee activities for 1990. Conditions are compared to guidelines for specific parameter values that were developed by the International Joint Commission under the 1977 Reference from Canada and the United States. References are made to State, Provincial, or Federal standards or objectives where these are relevant. After examination and evaluation of the monitoring information for 1990, the Committee finds that the measured conditions meet the recommended objectives.

In March 1991, the three year extension of the Cooperative Monitoring Arrangement expired. It is respectfully suggested that the Monitoring Arrangement be extended until the water apportionment and the water-quality objectives are formally adopted by the governments or until such time that the governments have finalized arrangements for another body to monitor developments in the Poplar River basin.

Herein is the tenth annual report of the Poplar River Bilateral Monitoring Committee.

Yours sincerely,

J. R. Knapton
Chair, United States Section

R. A. Halliday
Chair, Canadian Section

A. Wittich
Member, United States Section

D. D. Nargang
Member, Canadian Section

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HIGHLIGHTS FOR 1981-90

Monitoring information collected in Canada and the United States has been officially exchanged on a quarterly basis during the past 10 years. Sampling schedules, frequency of collection, and parameters were modified throughout this period as recommended by the Bilateral Monitoring Committee. These modifications were documented in Technical Monitoring Schedules that were updated annually.

Divisions of transboundary waters on the East Poplar River have been carried out by Saskatchewan and Montana according to apportionment recommendations made in 1976 by the Poplar River Task Force of the International Souris-Red River Engineering Board. Only unintentional minor deviations from the prescribed formula have occurred. The water divisions were done voluntarily without a formal apportionment agreement between the two countries.

Regional drought prevailed during much of the 1980's with conditions worsening in the last half of the decade. Using the Poplar River at the International Boundary as an indicator of basin runoff conditions, the years of 1987, 1988, and 1989 had respective flow volumes of 27, 7, and 28 percent of long-term averages. The 1990 runoff was 35 percent of long-term average. Recent volumes of Cookson Reservoir remain much less than full supply volume and rely to a large extent on contributions of ground-water pumpage from the abandond Coronach mine.

The concentrations of total dissolved solids and boron on the East Poplar River at the International Boundary have remained below short-term and long-term objectives as recommended by the International Joint Commission (IJC). Calculations of trends from the 10-year data base

indicate that total dissolved solids and boron had an average annual increase of 3.75 milligrams per liter (mg/L) and 0.0285 mg/L, respectively. Minor excursions of other water-quality objectives have occurred on occasion, but no excursions remained consistent with time. Concentrations of total dissolved solids and boron have increased with time upstream in Cookson Reservoir.

Monitoring of ground-water levels indicated that dewatering activities of the Coronach coal mine created a cone of depression that currently is fluctuating with the 1 metre drawdown contour approximately 1.8 kilometers north of the International Boundary. From 1987 through 1989, pumpage at the mine decreased by 62.4 percent. Pumpage for 1990 reflected an increase of 56 percent over that of 1989.

The calculated total seepage from the ash lagoons remains well below the seepage limits proposed in 1979 by the International Poplar River Water Quality Board of the International Joint Commission. The advancement of the groundwater front towards Cookson Reservoir in the oxidized till was calculated to be 15.42 metres since the lagoons were initially filled. The front in the Empress Gravel formation was calculated to have advanced 1,269 metres southeast of the lagoons.

In 1989, Prairie Coal Limited moved mining operations to the South Block (Willow Bunch Mine) which was developed in 1988. The Willow Bunch Mine will require little dewatering and therefore, not provide supplemental water to Cookson Reservoir. Although decreased from past pumpage, ground water continued to be pumped from the abandoned Coronach mine during 1990 to supplement Cookson Reservoir water supply.

Downstream from Cookson Reservoir and contiguous to the East Poplar River, the hydraulic head in a near-surface, semi-confined aquifer has increased over pre-reservoir times. During 1989-90, Sask Power installed a series of wells and initiated pumpage to lower the water table and reduce soil salinity. Pumped water is piped back to the reservoir. Monitoring wells were installed during 1990 in Montana near the International Boundary on both sides of the East Poplar River to measure potential trans-boundary affects of salinity and increased water levels.

Monitoring of air quality at designated sites in Saskatchewan began with startup of the first generating unit and has continued through 1990. Monitoring results in 1990 did not show any ambient sulphur dioxide excursions above Saskatchewan standards. There were no excursions from the suspended particulate monitor that could be attributed to power station activity. Air quality monitoring at three primary sites in Montana continued through 1986. After 1986, monitoring gradually was decreased and in 1990 Montana air-quality monitoring was discontinued. Monitoring results in Montana indicated that total suspended particulate standards for Montana and the United States were not exceeded at any of the three monitoring sites and that levels generally observed were low and representative of rural Montana.

INTRODUCTION

Sask Power (formerly Saskatchewan Power Corporation) applied to the Province of Saskatchewan in March 1972 for permission to store and use water from the East Poplar River. In July 1972, the Province reserved 7,400 cubic decametres (dam^3) (6,000 acre feet) of water annually for a period of five years for this purpose. In September 1974, Sask Power announced plans for the construction of a coal-fired thermal-electric generating station and ancillary facilities including a reservoir on the East Poplar River and a lignite coal mine at Coronach, Saskatchewan near the International Boundary. Subsequently, Morrison Dam (Cookson Reservoir impoundment) was completed in September 1976 and the first of two 300 megawatt generating units commenced commercial operation in June 1981 followed by the second unit in July 1983.

The IJC, through the Souris-Red Rivers Engineering Board, was advised of the proposal early in the process. The IJC advised the Governments of the United States and Canada in February 1975 that it had asked its International Souris-Red Rivers Engineering Board to review the proposal in light of a 1948 Reference dealing with water apportionment. The Commission also advised Governments that the project might adversely affect air quality and the quality of Poplar River water crossing the International Boundary and suggested that the Governments review the matter in light of the provisions of Article IV of the Boundary Waters Treaty. Water quantity, water quality, and air quality issues were raised in early 1975 in a diplomatic note from the Government of the United States to the Government of Canada.

The Poplar River Task Force of the International Souris-Red Rivers Engineering Board was formed in April 1975 to investigate the apportionment question pursuant to the 1948 Reference dealing with water

apportionment. In a subsequent report, the IJC recommended that transboundary flows be divided equally between the United States and Canada in accordance with a prescribed apportionment formula. To date, this recommendation has not been formalized by Provincial, State and Federal Governments.

In August 1977, the Governments of the United States and Canada, pursuant to Article IX of the Boundary Waters Treaty of 1909, referred the matter of water quality in the Poplar River Basin to the IJC. The reference specifically requested the IJC to examine and report on the water quality of the Poplar River, including the transboundary water quality implications of the thermal power station of Sask Power and its ancillary facilities. A study was completed by a multi-disciplinary team of scientists from Canada and the United States and a summary of findings and recommendations was published in January 1981.

The Poplar River Bilateral Monitoring Committee was authorized for an initial period of 5 years by the Governments of Canada and the United States under the Poplar River Cooperative Monitoring Arrangement dated September 23, 1980. A copy of the Arrangement is attached to this report as Annex 1. On March 12, 1987 the Arrangement was extended by the Governments for 4 years to March 1991.

The Committee is composed of representatives of the Government of the United States of America, State of Montana, and Government of Canada and Province of Saskatchewan. In addition to the representatives of Governments, two ex-officio members from the State of Montana and Province of Saskatchewan who reside in the Poplar River basin participate in the activities of the Committee. Table 1 lists the members and ex-officio members of the Committee during 1990.

Table 1. 1990 MEMBERSHIP OF THE POPLAR RIVER BILATERAL MONITORING COMMITTEE

UNITED STATES SECTION	CANADIAN SECTION
Mr. J.R. Knapton U.S. Geological Survey Chair	Mr. R.A. Halliday Environment Canada Chair
Mr. A. Wittich Governor's Office Member	Mr. D.D. Nargang Saskatchewan Environment Member
Mr. C.W. Tande Daniels County Commissioner Ex-Officio Member, Montana	Mr. J.R. Totton Reeve, R.M. of Hart Butte Ex-Officio Member, Saskatchewan

The monitoring programs are in response to potential impacts of a trans-boundary nature resulting from Sask Power's coal-fired thermal generating station and ancillary operations near Coronach, Saskatchewan. Monitoring is conducted in Canada and the United States at or near the International Boundary for quantity and quality of both surface and ground water and for air quality. Participants from both countries, including Federal, Provincial, and State agencies, are involved in monitoring.

The Committee submits an annual report to Governments that summarizes the monitoring results, evaluates apparent trends, and compares data to objectives or standards recommended by the IJC or to relevant Federal, State, or Provincial standards. The Committee is also responsible for drawing to the attention of Governments definitive changes in monitored parameters which may require immediate attention. Reports submitted to the Governments normally cover activities of the preceding year. Because 1990 is the tenth year of Committee involvement, this report includes a compilation of data for the period of 1981-90.

A responsibility of the Committee is to review the adequacy of the monitoring programs in both countries and make recommendations to Governments on the Technical Monitoring Schedules. The Schedules are updated annually for new and discontinued programs and for modifications in sampling frequencies, parameter lists, and analytical techniques of ongoing programs. The Technical Monitoring Schedules listed in the annual report (Annex 2) are given for the following year. The Committee will continue to review and propose changes to the Technical Monitoring Schedules as information requirements change.

Another responsibility of the Committee includes a quarterly exchange of data acquired through the monitoring programs. The exchange of monitoring information was initiated with the first quarter of 1981, and is an expansion of the informal quarterly information exchange program initiated between Canada and the United States in 1976. Special reports dealing with aspects of monitoring and monitoring results requested by the Committee are sometimes published. Any such reports are reviewed annually by the Committee. Reports reviewed by the Committee during 1990 are identified in Annex 3. Exchanged data and reports are available for public viewing at the agencies of the participating governments or from Committee members.

POPLAR RIVER POWER STATION

Operations

Operations at the Poplar River Power Station during 1990 were similar to previous years with both generating units providing base load capacity. Operating statistics for 1990 are shown in Table 2. No change in plant operations are anticipated for the next several years.

A historical review of the operations at the Poplar River Power Station from 1981 are provided in Figures 1, 2, and 3. Hours of operation for each unit are shown in Figure 1 and gross terawatt hours generated in Figure 2. The total coal burned and fuel oil used per year is illustrated on Figure 3.

Table 2.--*1990 Operating Statistics for Generating Unit No. 1 and No. 2.*

	Unit No. 1	Unit No. 2
Hours of Operation	7,989	8,012
Gross MHW generated	2,299,100	2,275,600
Availability (hours) [percent]	91.18	91.47
Capacity Factor (percent)	88.07	88.36
Number of Start-ups	5	5
Coal Consumed (tonnes)	1,920,821	1,901,697
Oil Consumed (tonnes)	972	1,129
Hours in period	8,760	8,760

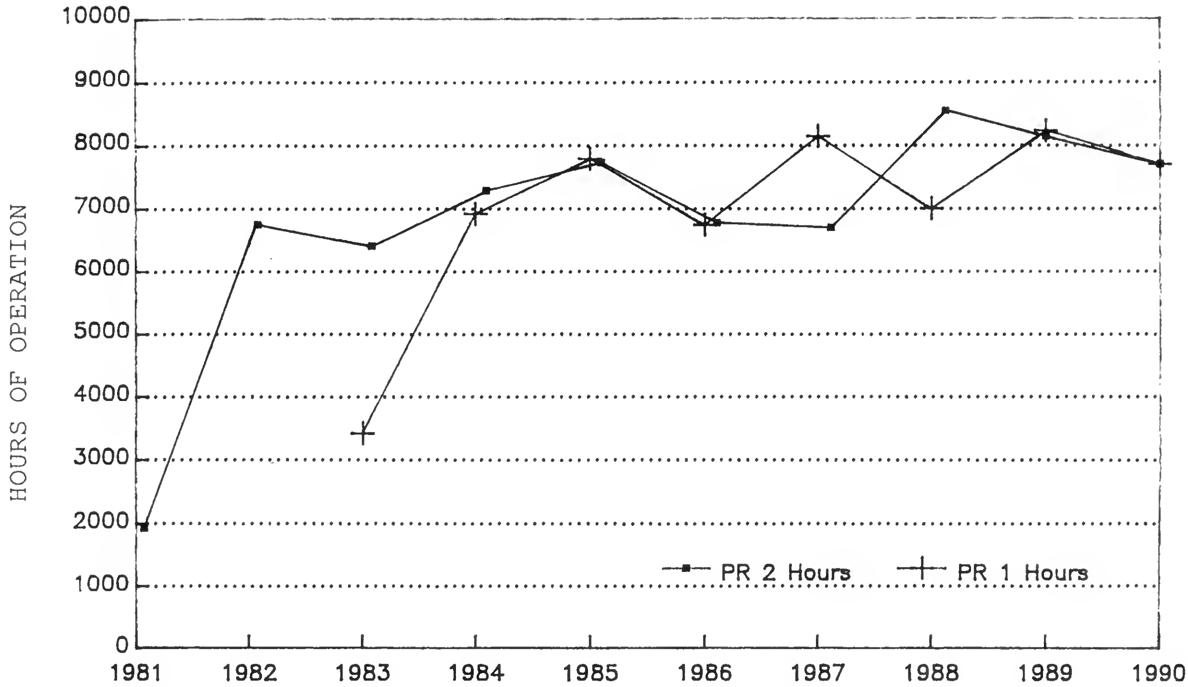


Figure 1.--Annual operating hours for Poplar River Power Station Units 1 and 2.

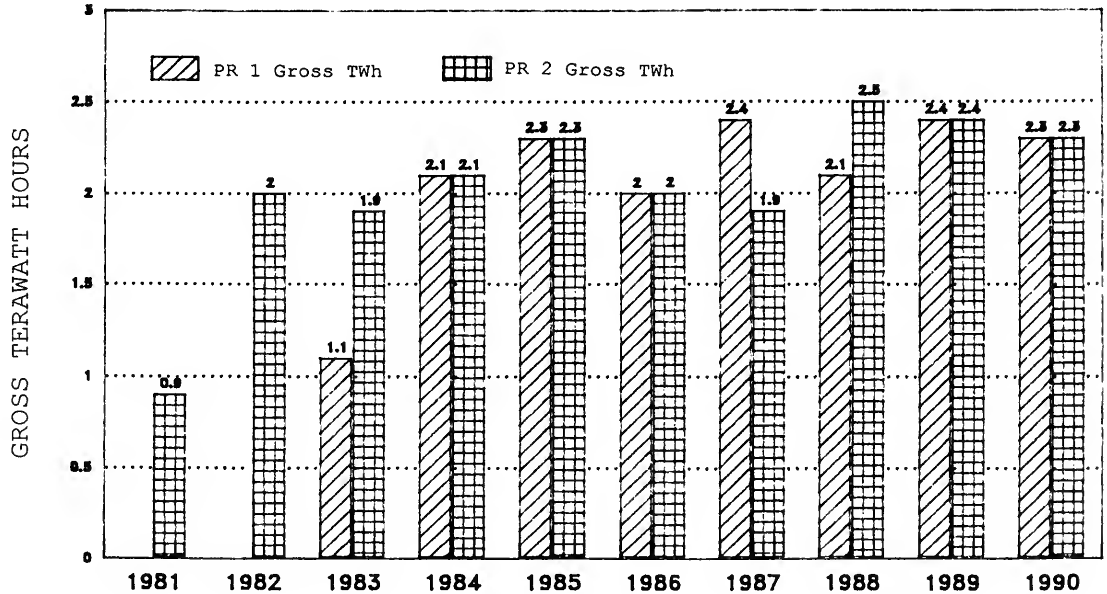


Figure 2.--Annual power production for Poplar River Power Station Units 1 and 2. Unit 1 in service from July 1983 and Unit 2 in service from June 1981.

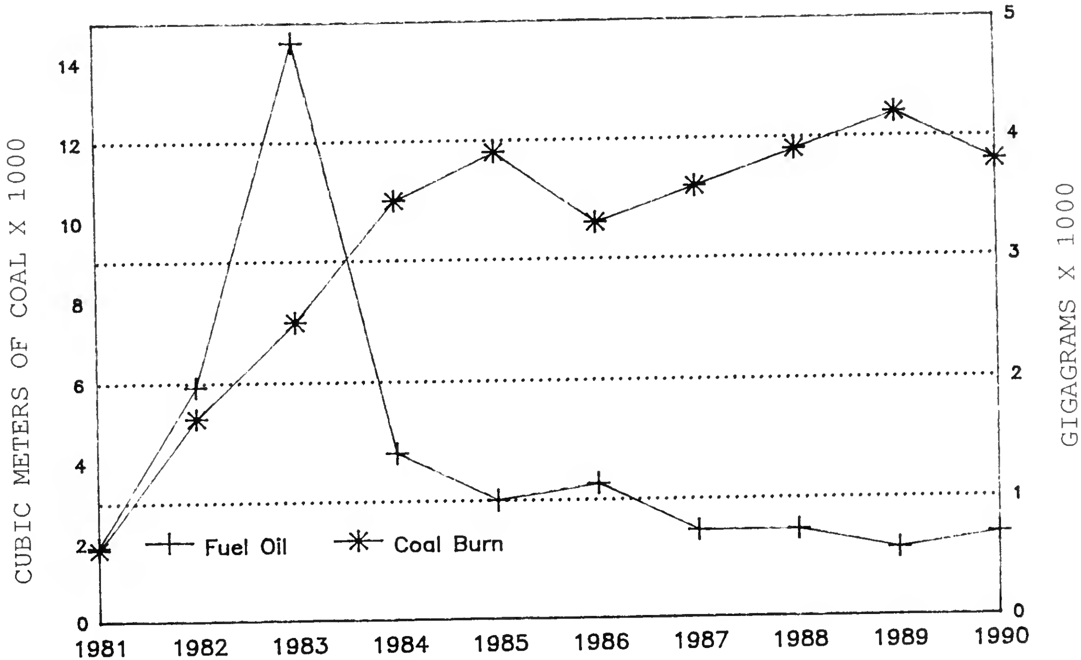


Figure 3.--Annual fuel consumption for fuel oil and coal at the Poplar River Power Station.

The average sulphur content of the coal in 1990 was 0.70 percent. Analysis was conducted by the Poplar River Power Station laboratory. Analysis of a monthly duplicate coal sample by an independent laboratory indicated, on average, a 0.1 percent lower value. Testing for both laboratories was done in accordance with ASTM procedure D3176. The sulphur content of the fuel oil was 0.08 percent.

General operations of the ash lagoons were similar to previous years. Ash Lagoon No. 1 was used in the winter, with ash split between Ash Lagoon No. 1 and Ash Lagoon No. 3 North in the summer. The Poplar River Power Station continues to surcharge ash in Ash Lagoon No. 1.

Similar operations are scheduled for 1991 but with more extensive use of Ash Lagoon No. 3 North planned over the summer months.

There was one reportable spill in 1990 due to human error. This spill involved the discharge of ash/ash water. All clean up activity related to this spill has been completed. No long term environmental damage as a result of this spill is likely. The ash line monitoring program continued.

In 1989 the "Soil Salinity Project South of Morrison Dam" was initiated with construction of four pumpwells and a connecting pipeline on the east side of the East Poplar River. Initial pumping to Cookson Reservoir started with one pump placed in service September 1989. By December, 1989, two more pumpwells were placed into service. Three pump operation continued to the end of 1990. Results for drawdown of groundwater elevations on the east side of the Poplar River have been encouraging.

In 1990, Sask Power assumed responsibility for the dewatering operations at the abandoned west block mine site. Water from this pumping is used to supplement the water supply in the Cookson Reservoir and to provide local domestic requirements.

Construction

Construction of a demonstration scale LIFAC flue gas desulfurization unit was completed on Poplar River's Unit No. 1 in the third quarter of 1990. The system was commissioned in September 1990 and extensive testing was done in the last quarter of 1990. Results of testing have been encouraging. Further testing is planned in 1991.

In 1990, four pumpwells and connecting pipeline were added to the "Soil Salinity Project South of Morrison Dam". These pumpwells were placed on the west side of the East Poplar River. Construction was completed in October 1990. By the end of 1990, two pumps were in service.

Mining

During 1990, Prairie Coal Limited provided coal to the Poplar River Power Station from the south block mine site located east of Coronach, Saskatchewan. Reclamation of the mined area at the west block mine site continued in 1990 and should be complete in 1992.

The mineable coal supply at the south block mine site is limited to three to four more years. As a result, Prairie Coal Limited plans to relocate mining in 1994 to the north block mine area located north of Coronach, Saskatchewan. Pre-mine development of the north block mine is scheduled for 1992. The overview of the three mining areas is provided by the map in Figure 4.

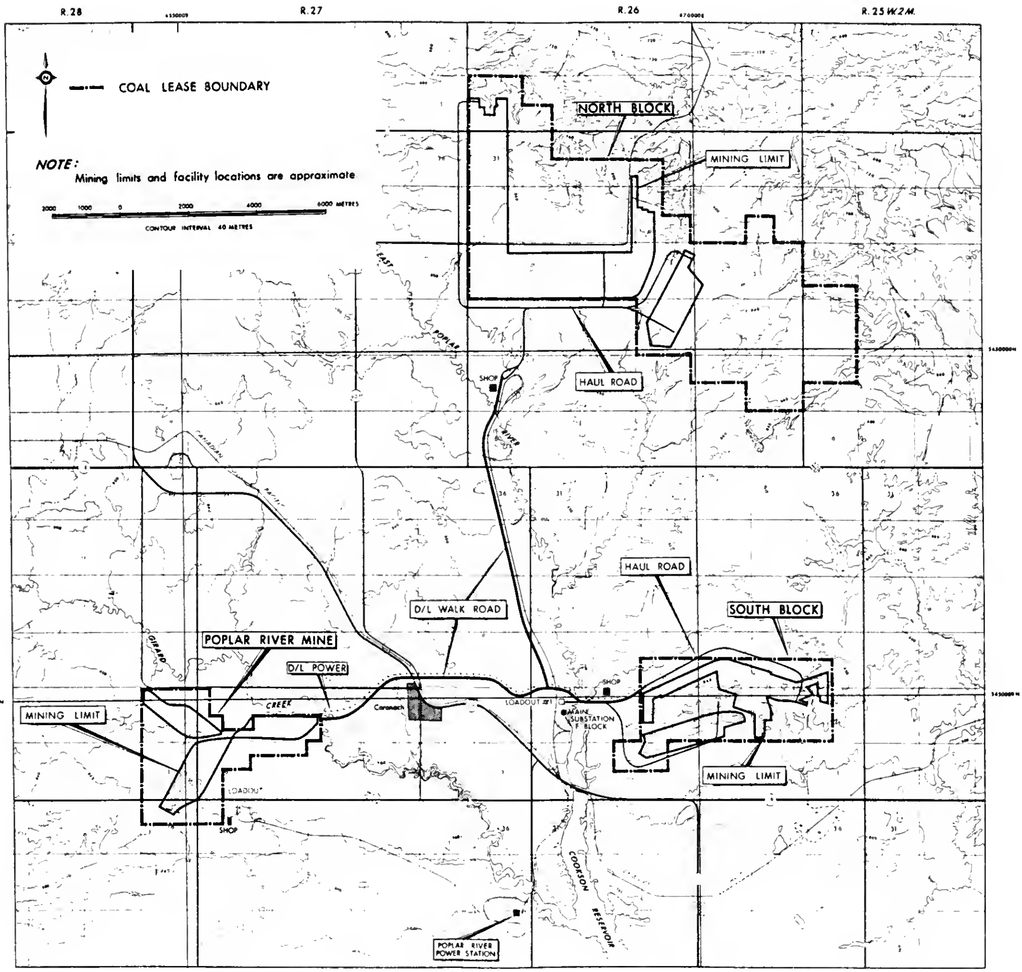


Figure 4.--Map showing past, present, and future coal mines used to supply the Poplar River Power Station.

SURFACE WATER QUANTITY

Streamflow

Streamflow in the Poplar River basin was much below normal during 1981-90. Median March to October runoff at the gaging station on the Poplar River at the International Boundary for the period was only 40 percent of the median of the previous 50 years of record. Streamflow was well below the long-term mean in all but two of ten years. Winter snowfall, spring rains, and summer thundershowers were all noticeably absent during the period. A comparison of the March-October runoff for 1981-90 with the long-term mean and median is shown in Figure 5.

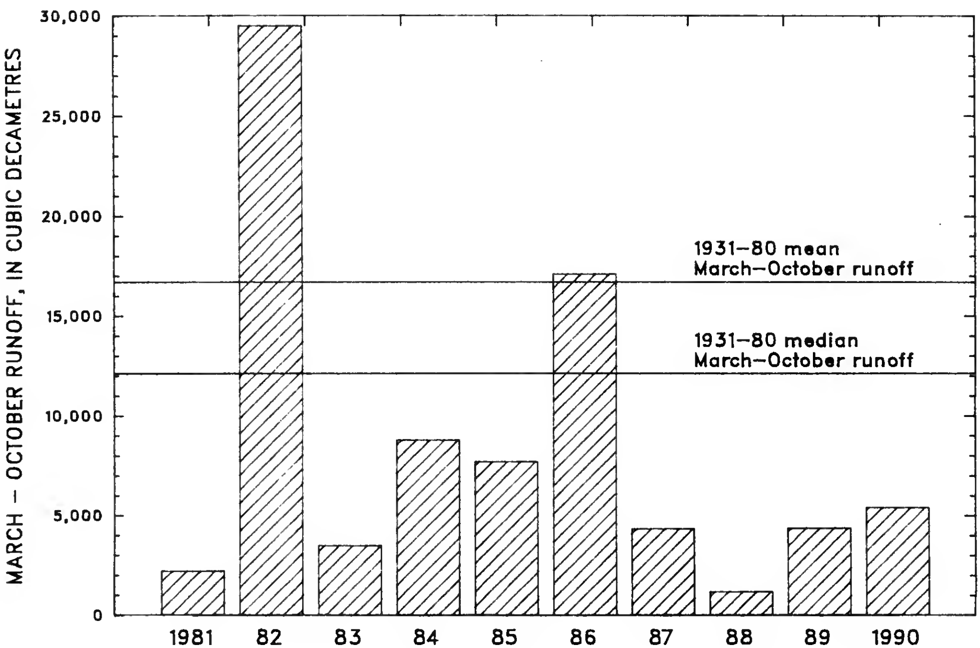


Figure 5.--March through October runoff for 1981-90 as compared to the 1931-80 mean and median runoff on the Poplar River at International Boundary.

Streamflow in the Poplar River basin was below normal during 1990. The March to October recorded flow volume of the Poplar River at the International Boundary was 5,410 cubic decametres (dam^3), or 32 percent of the 1931-80 mean.

Reservoir Storage

Cookson Reservoir, the source of cooling water for the Poplar River Power Station, was at full-supply level (FSL) for only three short periods in the period 1981-90. By the end of 1990, the contents of the reservoir had dropped to a ten-year low of 23,200 dam^3, or 53 percent of capacity. Full power plant production requires 18,000 dam^3 of water in the reservoir. The monthend contents and elevations for Cookson Reservoir for 1981-90 are shown in Figure 6.

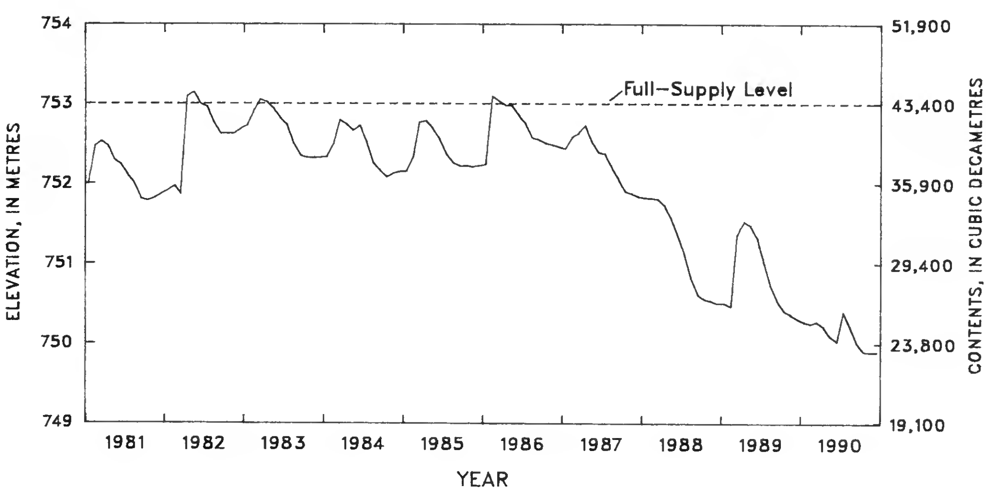


Figure 6.--Monthend contents and elevations for Cookson Reservoir.

Reservoir storage during the 1981-90 period was supplemented by ground water pumping for purposes of mine dewatering. In most of those years, the pumping exceeded the amount of water contributed by natural flow. An average of 5,400 dam^3 was pumped from the mine annually.

Apportionment

In 1976, the International Souris-Red Rivers Engineering Board, through its Poplar River Task Force, completed an investigation and made a recommendation to the governments of Canada and the United States regarding apportionment of the waters of the Poplar River basin. Although not officially adopted by the two countries, Canada has attempted to follow the apportionment recommendations.

The apportionment of the East Poplar River is determined on the basis of the natural flow of the Poplar River. Through 1990, the recorded flow of the Poplar River at the International Boundary was considered to be the natural flow. The recorded flow for the March-May period each year is used to determine the minimum flow and on-demand release requirements on the East Poplar River for the succeeding 12 months. Generally, the greater the flow in the Poplar River, the greater the releases into the East Poplar River. The complete apportionment recommendation is given in Annex 4.

Minimum Flows and On-Demand Releases

During the ten-year period, the flow in the East Poplar River has generally exceeded minimum flow requirements. However, flows did drop below the recommended minimum for short periods in 1982, 1986, and 1990. Main

causes of these shortages have been severe ice conditions, beaver activity, and miscommunication.

On-demand releases have been made as requested during the ten-year period. Inability to accurately control small releases from Cookson Reservoir has occasionally resulted in an extension of the requested release period. With the exception of 1981, when two consecutive releases were made, each year's on-demand release has been requested and made in April or May of the following year.

Figure 7 shows the recorded flow of the East Poplar River as compared to the combined minimum flow and on-demand release volume as given in the apportionment recommendation for 1981-90.

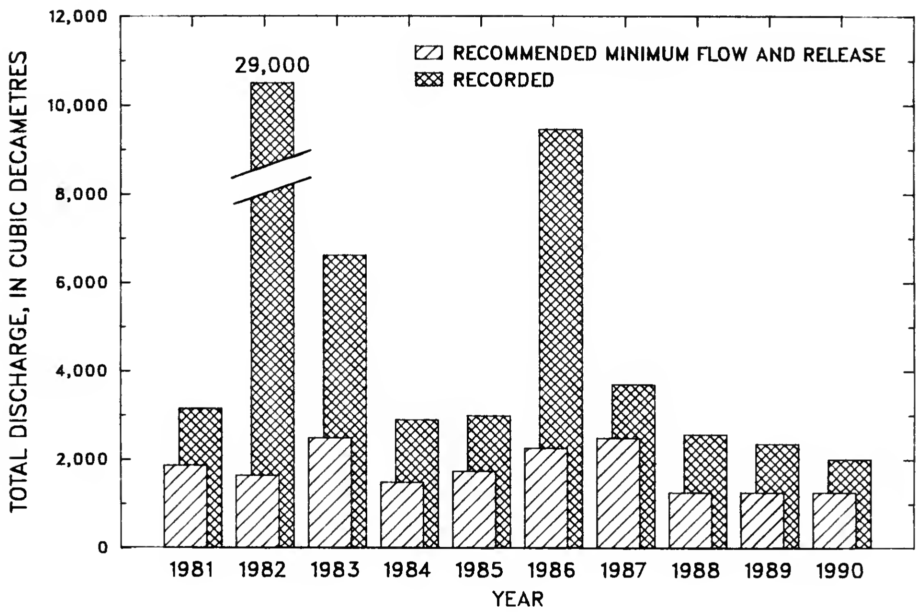


Figure 7.--Recorded discharge of the East Poplar River at International Boundary as compared to the total minimum flow recommendation.

In 1990, the recommended minimum daily flow of 0.028 cubic metres per second (m^3/s) was met or exceeded except on June 12 and December 30, 31. Releases to meet the on-demand volume of 370 dam^3 were made May 1-31. A salinity-control pumping project downstream from Cookson Reservoir and upstream from the International Boundary has lowered the groundwater table and, consequently, reduced the groundwater contribution to the flow of the East Poplar River at the International Boundary. A total of 705 dam^3 was pumped back into Cookson Reservoir from this project in 1990.

Quality Control

Simultaneous discharge measurements have been made by personnel from the U.S. Geological Survey and Water Survey of Canada annually since 1987. To date, all measurement results have been within acceptable limits, and many have compared exceptionally well.

1981-90 SURFACE WATER QUALITY

East Poplar River

The 1981 report by the IJC to Governments recommended:

> *For the March to October period, the maximum flow-weighted concentrations should not exceed 3.5 mg/L for boron and 1500 mg/L for total dissolved solids for any three consecutive months in the East Poplar River at the International Boundary. For the March to October period, the long-term average of flow-weighted concentrations should be 2.5 mg/L or less for boron, and 1000 mg/L or less for total dissolved solids in the East Poplar River at the International Boundary.*

For the period prior to 1982, three-month moving flow-weighted concentrations (FWC) for boron and total dissolved solids (TDS) were calculated solely from monthly monitoring results. Since the beginning of 1982, the U.S. Geological Survey (USGS) has monitored specific conductance daily in the East Poplar River at the International Boundary, allowing estimates of daily boron and TDS concentration to be derived from regression relationships with specific conductance. Thus, three-month FWCs for the period 1982 to 1988 have been calculated from both the results of monthly monitoring and the daily concentration estimates.

The Bilateral Monitoring Committee adopted the approach that for the purposes of comparison with the proposed IJC long-term objectives, the boron and TDS data are best graphically plotted as five-year moving FWCs which were advanced one month at a time.

Beginning in 1988, FWCs were calculated from the five year period preceding each plotted point. Prior to 1988, long-term averages were calculated from a five year period in which 2.5 years preceded and 2.5 years followed each plotted point. For example, the FWC for December

1989 refers to the FWC of the period December 1984 to December 1989. It should be emphasized that the calculations have been based on the results of all samples collected for the three-month and five-year period, and not restricted to samples collected during March to October.

Total Dissolved Solids

There is an inverse relationship between TDS and streamflow at the International Boundary station. During periods of high runoff, such as spring freshet, TDS drops as the proportion of streamflow derived ultimately from groundwater decreases. Conversely, during times of low streamflow (late summer, winter) the contribution of groundwater to streamflow is proportionally greater. Because the natural groundwater has a higher ionic strength than the surface water entering the river, the TDS of the stream increases markedly during low flow conditions.

TDS grab sample data collected by Environment Canada and the USGS from January 1981 to December 1990 are shown in Figure 8. In Figure 9, individual years are simplified by annual box plots. For any one year the maximum and minimum values are displayed by lines extending from a box. The box displays the 25th, 50th (median), and 75th percentiles for that year. Except for 1982 and 1983, the data ranges remain somewhat close to the median. In 1982 and 1983, high flow conditions (Figure 10) likely explain the extremely low TDS values. The TDS observations at the higher end of the concentration range are probably a consequence of groundwater contributions to streamflow during low flow conditions. Seasonally, the lowest TDS concentrations occur from March to May coinciding with high flow conditions (Figures 11 and 12).

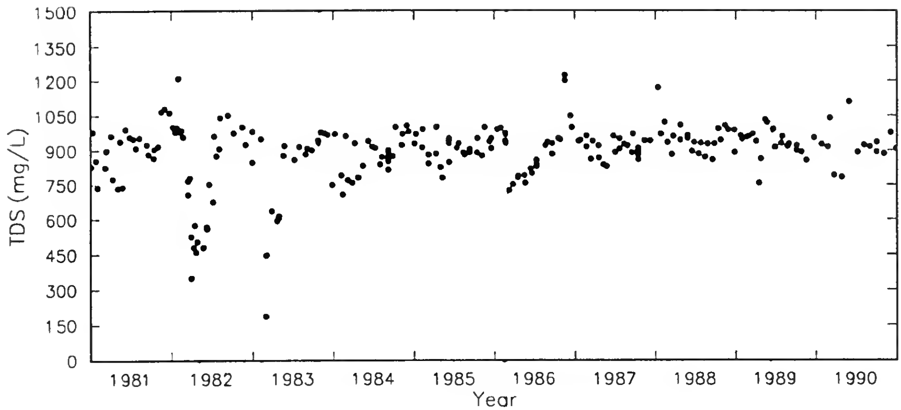


Figure 8.--TDS grab sample data for East Poplar River at International Boundary for period 1981-90.

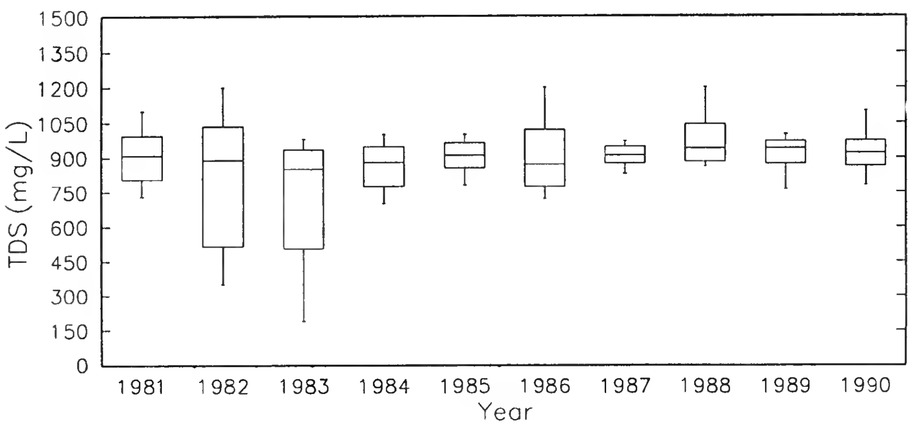


Figure 9.--Box plots of annual TDS concentrations for East Poplar River at International Boundary for period 1981-90.

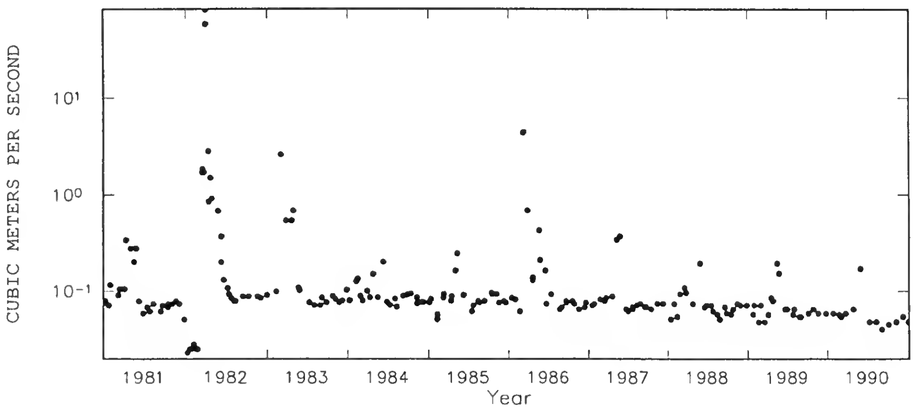


Figure 10.--Mean daily discharge for water-quality sampling dates for East Poplar River at International Boundary.

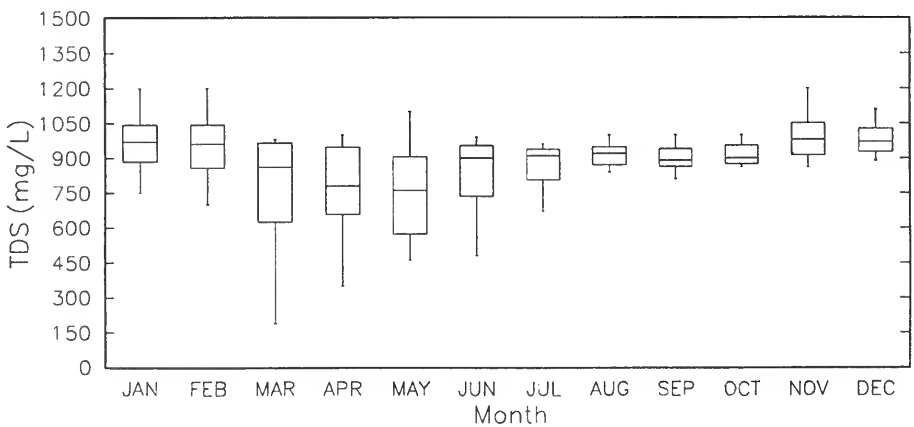


Figure 11.--Box plots of monthly TDS concentrations for East Poplar River at International Boundary for period 1981-90.

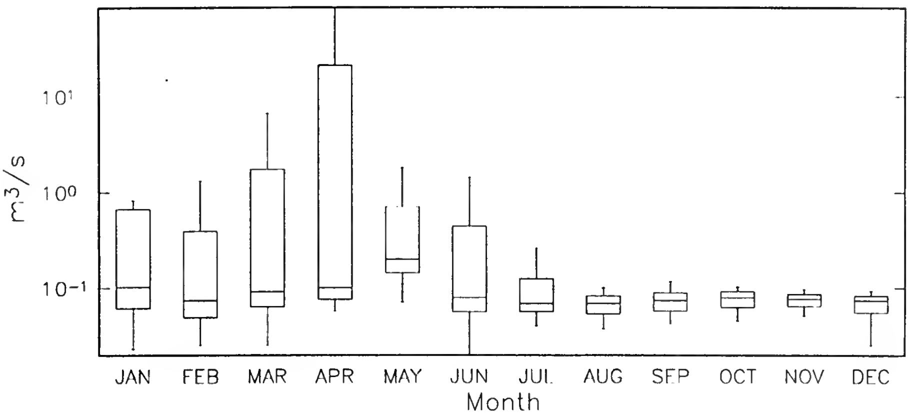


Figure 12.--Monthly boxplots of streamflows for samples collected at East Poplar River at International Boundary for period 1981-90.

A histogram and summary statistics for TDS are shown in Figure 13. The data are not normally distributed (90% confidence level), showing a significant negative skew. Using the Seasonal Kendall Tau test for trend assessment, TDS statistically increases significantly from 1981 to 1990 (90% confidence level). The Seasonal Kendall Sen Slope estimates the approximate TDS increase to be 3.75 mg/L/year (Figure 14). This positive trend could be explained by the drought conditions that occurred over the later half of the data record. Low flow conditions (when flows are derived largely from groundwater sources) likely increased TDS concentrations and yielded a positive TDS trend in the 1981-90 data. In addition, increases in TDS come from salt buildup in the reservoir as a result of evaporation. Natural reservoir evaporation is augmented by heat transfer from the generating units to the reservoir as water is used for cooling purposes.

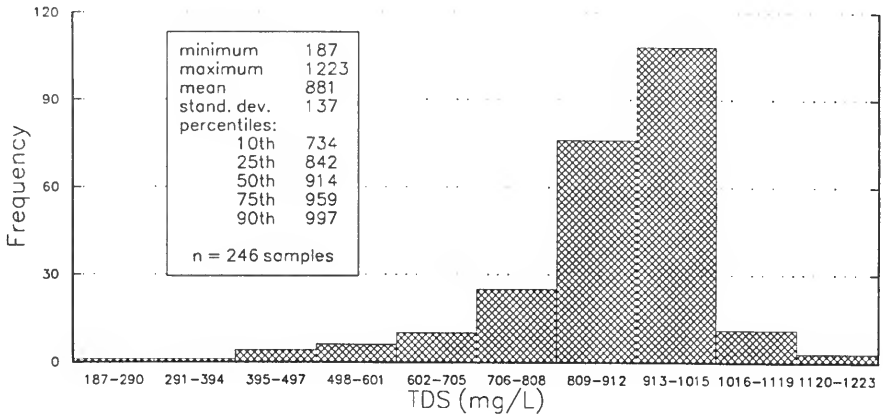


Figure 13.--Distribution of TDS concentrations for East Poplar River at International Boundary for period 1981-90.

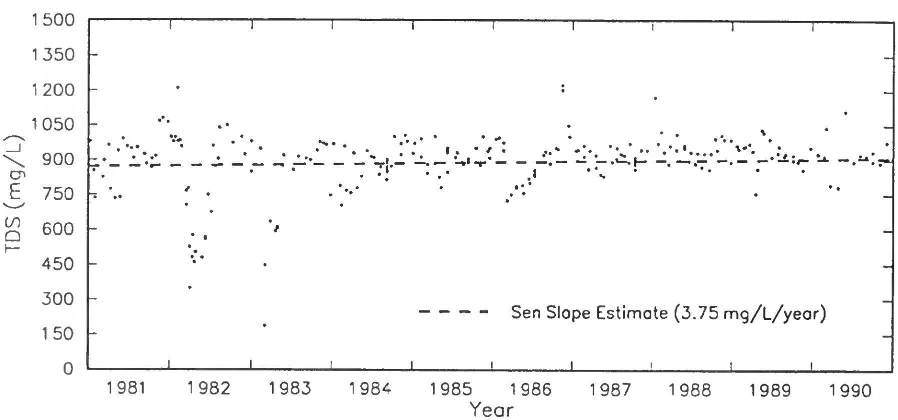


Figure 14.--Sen Slope estimate for TDS at East Poplar River at International boundary.

The proposed short-term objective for TDS is 1,500 mg/L. A time plot of the three-month moving FWCs for TDS is presented in Figure 15. No exceedances of the objective have been observed during any three month period since 1975. The three-month FWCs remained confined within a narrow range centered around a mean of approximately 900 mg/L during 1990.

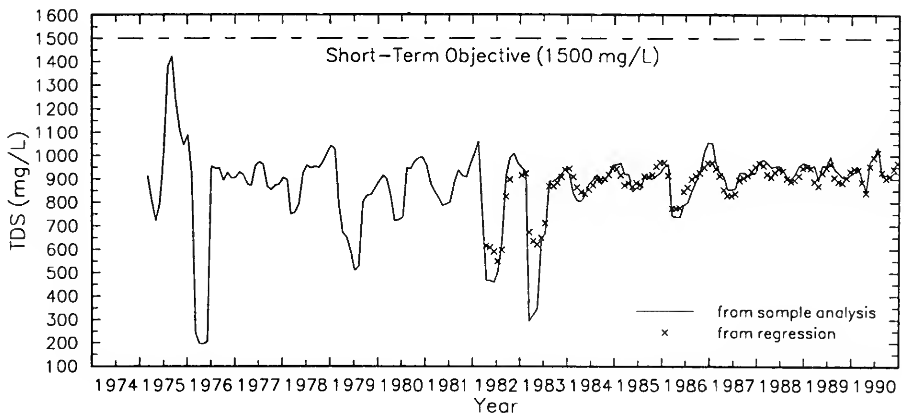


Figure 15.--Three-month moving, flow-weighted TDS concentration for East Poplar River at International Boundary.

Five-year FWCs for TDS (Figure 16) remained below the long-term objective of 1,000 mg/L. A 200 mg/L increase in the five-year FWCs which occured in early 1988 was maintained throughout 1990. This corresponds to a decline in high 1984 spring flows over that period of time. A similar increase in TDS was seen during mid 1987, as a remnant of 1982 discharge. Relatively low spring discharges have occurred since 1984. If this trend continues, it is expected that FWCs will increase slightly or remain near the present concentration level.

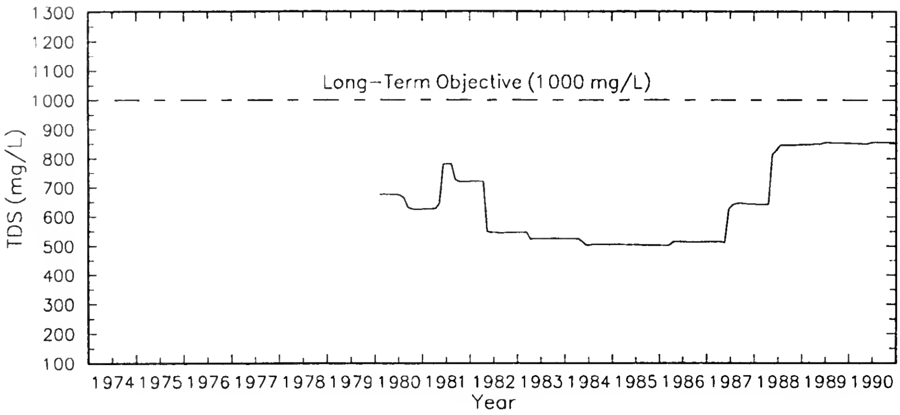


Figure 16.--Five-year moving, flow-weighted TDS concentration for East Poplar River at International Boundary.

The relationship between TDS and specific conductance generated from data collected from 1975 to 1990 is as follows:

$$TDS = (0.640 \times \text{specific conductance}) + 10.701$$

$$(R^2 = 0.87,\ n = 398)$$

Boron

Figure 17 displays monthly boron data collected from Jan. 1981 to Dec. 1990 by Environment Canada and the USGS. In Figure 18, individual years are simplified by annual box plots. Within any year, boron displays a marked variability about the median. The lowest boron concentrations occurred in 1982, 1983, and 1986 presumably as a result of high flow

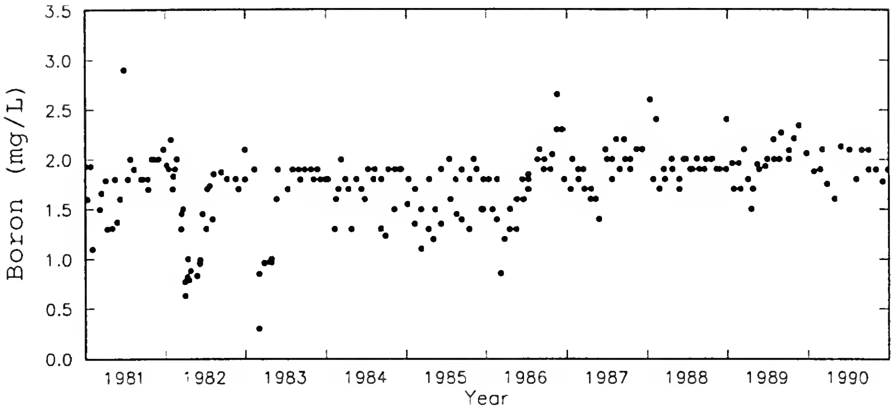


Figure 17.--Boron grab sample data for East Poplar River at International Boundary for period 1981-90.

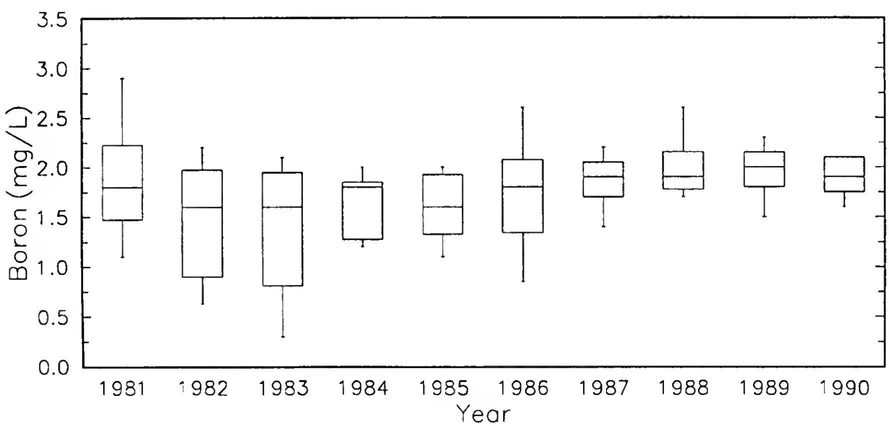


Figure 18.--Box plots of annual boron concentrations for East Poplar River at International Boundary for period 1981-90.

conditions (Figure 10). The highest boron concentrations occurred in 1981, 1986, and 1988 and are likely the product of low flow conditions. The seasonal boron pattern observed in Figure 19 closely resembles that of TDS (Figure 11); the lowest boron concentrations occur from March to July coinciding with high flow conditions.

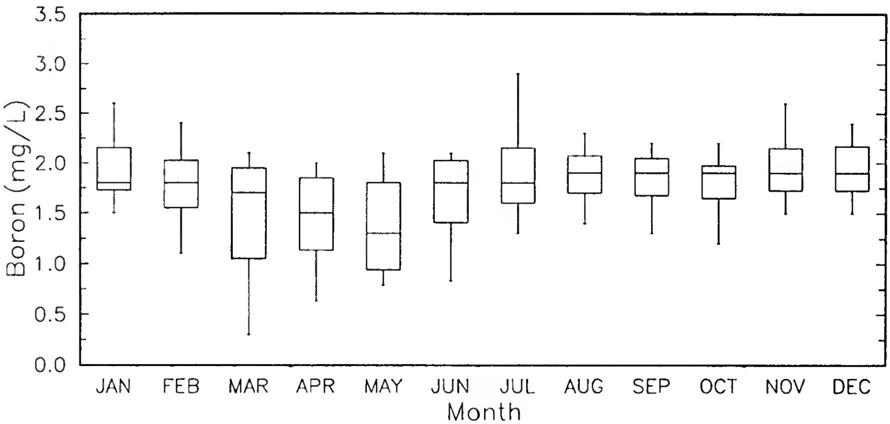


Figure 19.--Box plots of monthly boron concentrations for East Poplar River at International Boundary for period 1981-90.

The histogram and summary statistics for boron are shown in Figure 20. As with TDS, boron data are not normally distributed (90% confidence level), showing a significant negative skew. As shown in Figure 21, boron levels undergo a statistically significant increase from 1981 to 1990 (90% confidence level). The boron increase, as calculated by the Seasonal Kendall Sen Slope Estimate, is approximately 0.0285 mg/L/year. As with TDS, this trend may be explained by the drought conditions in addition to consumptive use of water for cooling and natural evaporation from Cookson Reservoir.

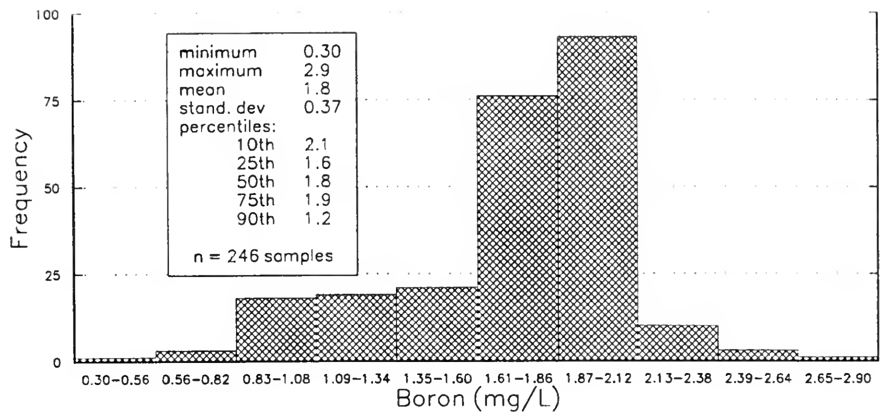


Figure 20.--Distribution of boron concentrations for East Poplar River at International Boundary for period 1981-90.

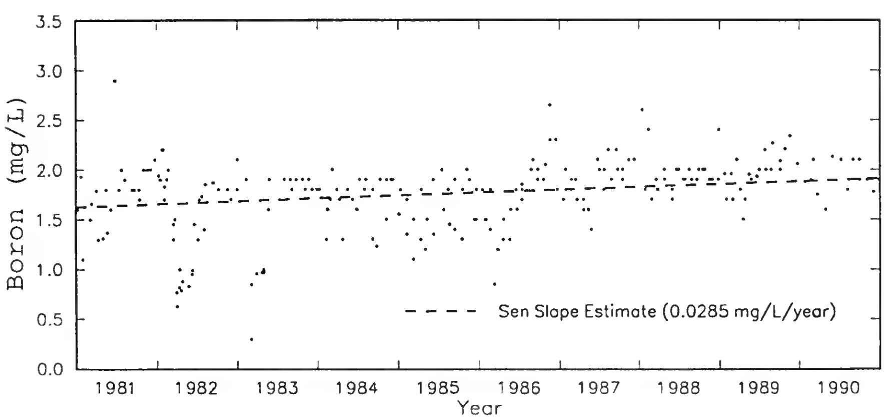


Figure 21.--Sen Slope estimate for boron at East Poplar River at International Boundary.

Three-month boron FWCs for the period of record are shown in Figure 22. The short term objective of 3.5 mg/L boron was not exceeded for the period 1975-1990. The similarity in shape between the TDS and boron plots (Figures 15 and 22) is a strong indication of the significance of discharge in FWC functions.

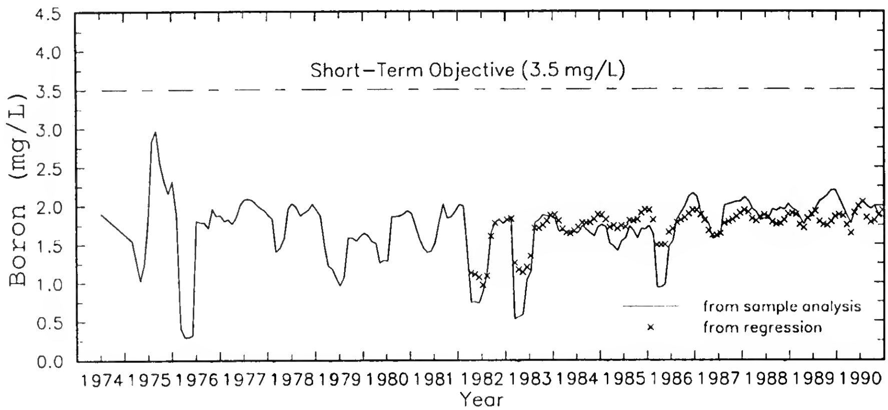


Figure 22.--Three-month moving, flow-weighted boron concentration for East Poplar River at International Boundary.

The five-year boron FWCs, displayed in Figure 23, remained well below the long-term objective of 2.5 mg/L boron. From mid-1988 to the end of 1990, there was a slight increase in the five-year boron FWC. As was the case with TDS, the five-year calculations for boron were significantly influenced by the relatively large discharge during the spring of 1985.

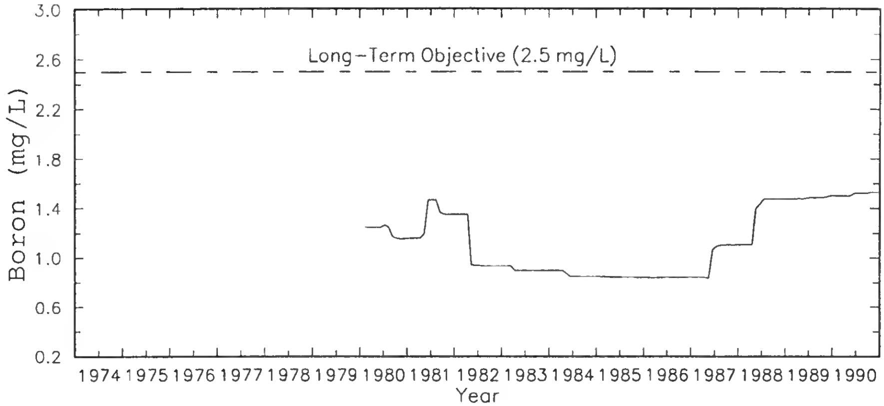


Figure 23.--Five-year moving, flow-weighted boron concentration for East Poplar River at International Boundary.

The relationship between boron and specific conductance at the East Poplar River sampling location during the period 1975-1990 is described by the equation:

$$\text{boron} = (0.00149 \times \text{specific conductance}) - 0.275$$

$$(R^2 = 0.71,\ n = 398)$$

Mercury in Cookson Fish

Mercury levels in fish in the Cookson Reservoir have been measured on four occasions, in 1979 and 1983 by Environment Canada (Water Quality Branch, 1980; Munro, 1985), and in 1980 and 1984 by Saskatchewan Environment (Waite and others, 1980). These fish were collected for the purpose of meeting consumptive guidelines. The fish are confined to Cookson

Reservoir and as such could only travel downstream as a result of a high runoff event. As suggested by Waite and others (1980), based on patterns in other reservoir flooding throughout the world, high initial mercury levels in fish would be expected as a consequence of organic decay and methylation of sediment-borne metal. Elevated mercury concentrations in fish tissues would decline to pre-flooding background levels as organic matter was assimilated.

Mercury concentration in edible tissue of two size-classes of walleye (*Stizostedion vitreum) from* 1979 to 1983 (Figure 24) followed the

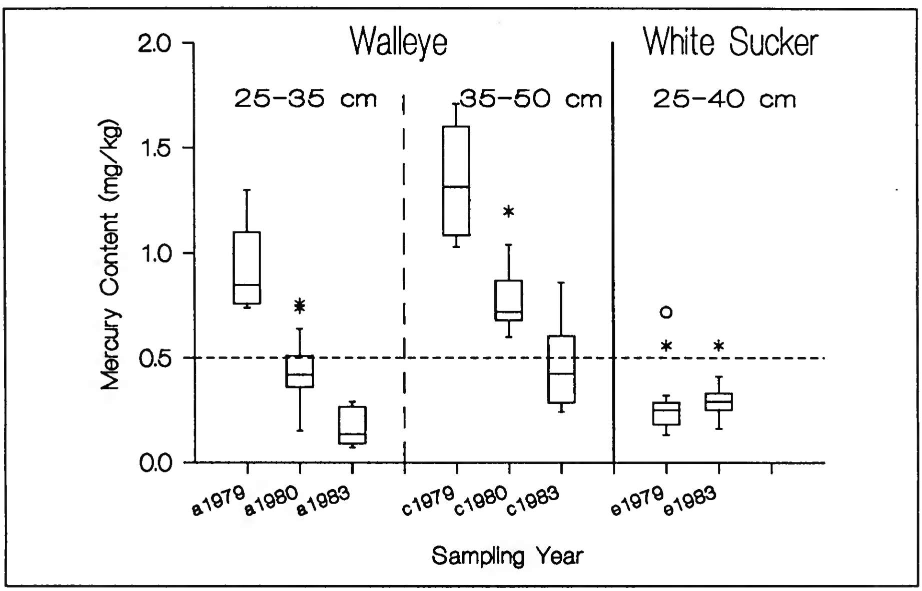


Figure 24.--Box plots of mercury levels in edible fish in Cookson Reservoir from 1979 to 1983. Data from Water Quality Branch (1980), Waite and others (1980) and Munro (1985). Dashed horizontal line indicates current consumption guideline of 0.5 mg/kg.

expected pattern. Mercury in the edible tissue of smaller classes of walleye (25-35 cm) rapidly declined from a median concentration of 0.85 milligrams per kilogram (mg/kg) in 1979 to 0.14 mg/kg in 1983. Likewise, the mercury concentration in larger fish (35-50 cm), while remaining higher than the smaller fish, declined from 1.32 mg/kg in 1979 to 0.42 mg/kg in 1984. Mercury concentration of Cookson Reservoir white suckers (*Catastomus commersoni*) was low (median 0.25-0.29 mg/kg) and unchanged from 1979 to 1983 (Kruskal-Wallis 2-sample test, p=0.61). Munro (1985) also reported on several species of "forage fish", such as brassy minnow (*Hybognathus hankinsoni*) and less than one year old carp (*Cyprinus carpio*) and suckers. Values for these three fish species ranged from 0.03 to 0.25 mg/kg.

Other Water Quality Variables

Table 3 contains a summary of excursions, for the period 1981 to 1990, to the multi-purpose water quality objectives for the East Poplar River at the International Boundary. There were no exceedances of the objectives recommended by the IJC for TDS and boron. The following exceedances were observed for the objectives recommended by the International Poplar River Board to the IJC:

Parameter	Objective (mg/L)	Sample value (mg/L)	Sampling Date	Agency
Dissolved aluminum	0.1	0.11	June 19, 1984	Environment Canada
Dissolved oxygen	5.0/4.0	3.6	July 15, 1988	USGS
Dissolved oxygen	5.0/4.0	1.6	Jan. 11, 1989	Environment Canada
Dissolved oxygen	5.0/4.0	2.8	Feb. 8, 1989	Environment Canada
Dissolved oxygen	5.0/4.0	1.8	March 6, 1989	Environment Canada
Total zinc	.03	.10	April 15, 1982	USGS

Table 3.--*Recommended water quality objectives and excursions, 1981-90 monitoring, East Poplar River at the International Boundary*

[units in mg/L except as otherwise noted]

Parameter	Objective	No. of samples USA	No. of samples Canada	Excursions (No./Year)
Objectives recommended by IJC to Governments				
Boron-total	3.5/2.5([1])	113	134	nil
Total dissolved solids	1,500/1,000([1])	113	133	nil
Objectives recommended by Poplar River Board to IJC				
Aluminum-dissolved	0.1	31	97	1/1984
Ammonia un-ionized (as N)	.2	114	128	nil
Cadmium-total	.0012	15	127	nil
Chromium-total	.05	28	104	nil
Copper-dissolved	.005	20	--	nil
Copper-total	1.0	27	126	nil
Fluoride-dissolved	1.5	114	123	nil
Lead-total	.03	30	126	nil
Mercury-dissolved	.0002	15	114([2])	nil
Mercury-whole fish (mg/kg)	.5	--	56	4/1983
Nitrate (as N)	10.0	108	128	nil
Oxygen-dissolved	4.0/5.0([3])	112	117	1/1988; 3/1989
Sodium adsorption ratio	10	114	98	nil
Sulfate-dissolved	800	114	126	nil
Zinc-total	.03	35	124	1/1982
Water temperature (Celsius)	30.0([4])	118	113	nil
pH (pH units)	6.5([5])	110	123	nil
Coliform				
Fecal (no. per 100 mL)	2,000	11	107	nil
Total (no. per 100 mL)	20,000	11	100	nil

[1] Five-year average of flow-weighted concentrations (March to October) should be <2.5 boron and <1,000 TDS. Three-month average of flow-weighted concentrations should be <3.5 boron and <1,500 TDS.

[2] Mercury sampled by Environment Canada as total mercury.

[3] 5.0 (minimum April 10 to May 15), 4.0 (minimum remainder of year).

[4] Natural temperature (April 10 to May 15), <30 degrees Celsius (remainder of year).

[5] Less than 0.5 pH units above natural, minimum pH = 6.5.

1990 SURFACE WATER QUALITY

East Poplar River

Total Dissolved Solids

Analyzed TDS concentrations in 1990 ranged from 783 mg/L (April 10) to 1,110 mg/L (May 11). 1990 TDS results are presented in Figure 25. As mentioned in the 1981-90 section, there were no exceedences in 1990 of either the three-month FWCs or the five-year FWCs for TDS.

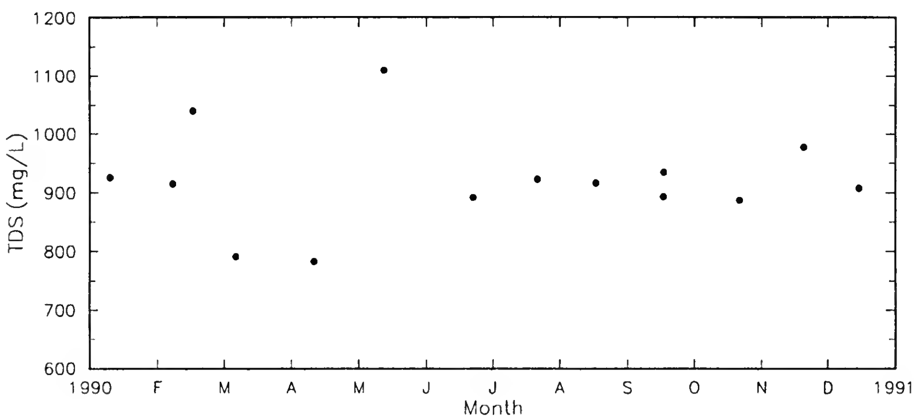


Figure 25.--TDS concentrations for 1990 grab samples from East Poplar River at International Boundary.

Boron

During 1990, boron concentrations in the East Poplar River at the International Boundary varied from 1.6 mg/L (April 10) to 2.1 mg/L (May 11) (Figure 26). In 1990, boron did not exceed either the three-month FWCs or the five-year FWCs.

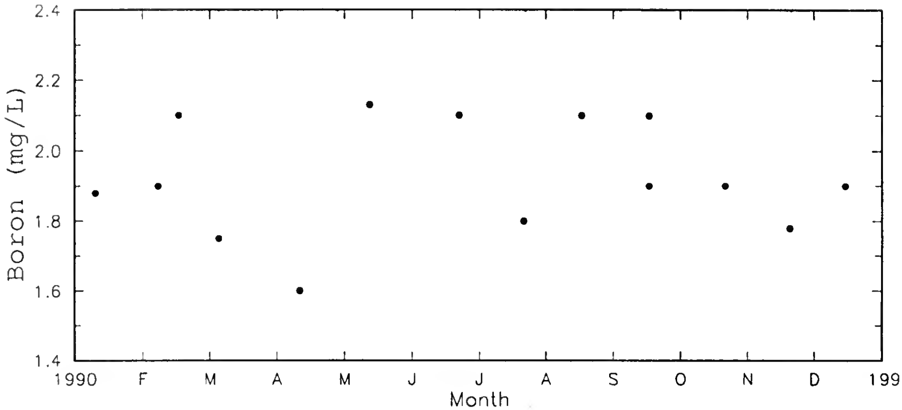


Figure 26.--Boron concentrations for 1990 grab samples from East Poplar River at International Boundary.

Other Water Quality Variables

Table 4 compares the concentration values for the remaining water quality variables to the multipurpose water quality objectives recommended by the International Poplar River Water Quality Board to the IJC. In 1990, there were no exceedences of these objectives.

Environment Canada monitored the East Poplar River for phenoxyacid herbicides and organochlorine compounds during 1990. Trace concentrations of 2,4-D (in one of eight samples), and alpha BHC (in one of nine samples) were recorded. The presence of these compounds in prairie surface waters is well documented (Integrated Environments Limited, 1991). All other organic compounds monitored were below analytical detection limits.

Table 4.--*Recommended water quality objectives and excursions, 1990 sampling program, East Poplar River at the International Boundary*

[units in mg/L except as otherwise noted])

Parameter	Objective	No. of samples USA	No. of samples Canada	Excursions (No./Year)
Objectives recommended by IJC to Governments				
Boron-total	3.5/2.5([1])	9	9	nil
Total dissolved solids	1,500/1,000([1])	9	9	nil
Objectives recommended by Poplar River Board to IJC				
Aluminum-dissolved	0.1	4	9	nil
Ammonia un-ionized (as N)	.2	9	9	nil
Cadmium-total	.0012	1	9	nil
Chromium-total	.05	3	9	nil
Copper-dissolved	.005	2	--	nil
Copper-total	1.0	3	9	nil
Fluoride-dissolved	1.5	9	9	nil
Lead-total	.03	3	9	nil
Mercury-dissolved	.0002	--	--	nil
Mercury-whole fish (mg/kg)	.5	--	--	nil
Nitrate (as N)	10	3	9	nil
Oxygen-dissolved	4.0/5.0([2])	9	7	nil
Sodium adsorption ratio	10	9	9	nil
Sulfate-dissolved	800	9	9	nil
Zinc-total	.03	2	9	nil
Water temperature (Celsius)	30.0([3])	9	7	nil
pH (pH units)	6.5([4])	9	9	nil
Coliform				
Fecal (no. per 100 mL)	2,000	--	9	nil
Total (no. per 100 mL)	20,000	--	9	nil

[1] Five-year average of flow-weighted concentrations (March to October) should be <2.5 boron and 1,000 TDS. Three-month average of flow-weighted concentrations should be <3.5 boron and <1,500 TDS.

[2] 5.0 (minimum April 10 to May 15), 4.0 (minimum remainder of year).

[3] Natural temperature (April 10 to May 15), <30 degrees Celsius (remainder of year).

[4] Less than 0.5 pH units above natural, minimum pH = 6.5.

Girard Creek and Cookson Reservoir

1981-1990

The 1981-90 Cookson Reservoir data for TDS and boron collected prior to freezeup conditions illustrate increasing trends. A review of concurrent reservoir volumes and the declining trend over the past four years suggest the low inflows may have exacerbated the upward trend. During the same review period, the East Poplar and Girard Creek inflows demonstrated annual variability but long term trends were not apparent.

The major ion compositions in early winter samples collected in 1980, 1981, 1985, and 1990 from Cookson Reservoir near Morrison Dam and at Highway 36, and Girard Creek were examined. The ionic characteristics have remained generally similar although some subtle changes in composition have occurred. The shifts have primarily related to the magnesium, sodium plus potassium, bicarbonate and sulphate ions.

Over the 1981-90 period, the water quality has essentially been within the objectives established for the East Poplar River at the international boundary (Table 5). Apart from TDS and boron, percentile ranges and trends for the remaining variables have been as listed in Table 5.

Table 5.--*Historical quality summary, Cookson Reservoir near Morrison Dam*

[Note: Units in mg/L unless noted. Trends based on fall data.]

			Percentile Range		
Parameter	Record	Analyses	10th	90th	Trend
Aluminum-total	8004-9011	63	0.08	0.88	nil
Ammonia (As N)-total	8004-9011	58	.06	.37	nil
Cadmium-total	8004-9011	55	<.001	<.001	nil
Chromium-total	8004-9011	90	<.001	.005	nil
Copper-total	8004-9011	100	.001	.006	nil
Fluoride-dissolved	8004-9011	59	.17	.50	post 85 increase
Lead-total	8004-9011	31	<.004	.006	nil
Mercury-total	8004-9011	55	<.0001	.0002	nil
Nitrate/Nitrite (as N)	8004-9011	68	.02	.32	nil
Oxygen-dissolved	8004-9011		6.2	10.7	--
Sulphate-dissolved	8004-9011	67	160	360	increasing
Zinc-total	8004-9011	89	.002	.031	nil
Temperature, °C	8004-9012	140	3.0	24.5	--
pH, units	8004-9012	269	8.68	8.8	increasing
Total Coliform/dL	8004-9011	65	<1	50	nil
Fecal Coliform/dL	8004-9011	65	<1	2	nil

1990

Saskatchewan Environment and Public Safety reported quarterly on the water quality at four locations in the Poplar River Basin during 1990. Sites included Girard Creek south of Coronach, Cookson Reservoir at Highway 36, Cookson Reservoir near Morrison Dam, and East Poplar River immediately below Morrison Dam. Sampling at these sites was carried out in February, May, August, and November.

A review of the data from these locations showed concentrations of virtually all water quality variables to be within the recommended water-quality objectives for the East Poplar River (Table 4). At the Girard Creek station, single anomalous excursions were noted for zinc and chromium. Spring runoff in 1990 was much below the long term normal. Reservoir water quality (dissolved salts) improved only marginally in the spring relative to the preceding winter water quality. Figures 27, 28,

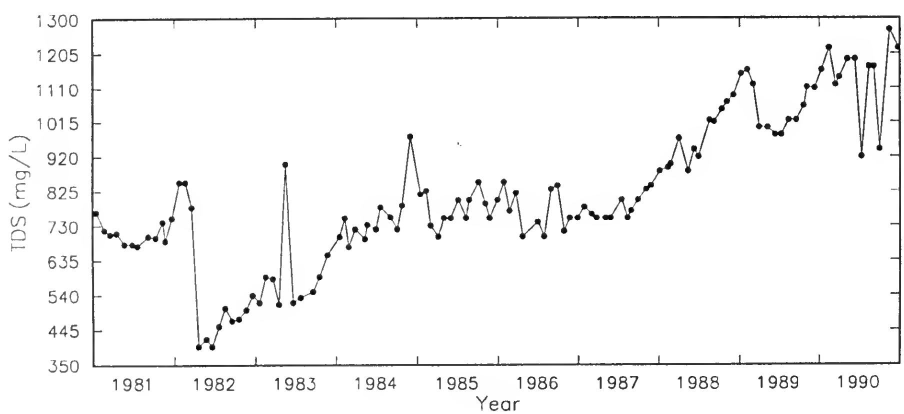


Figure 27.--TDS concentrations in Cookson Reservoir at Morrison Dam for the period 1981-90.

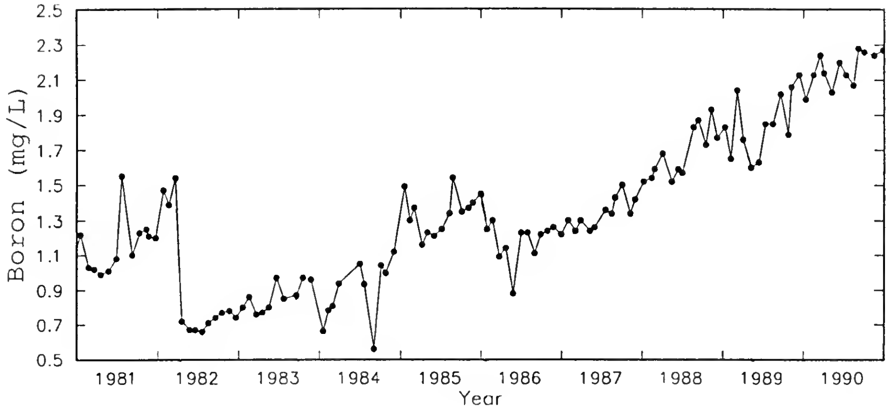


Figure 28.--Boron concentrations in Cookson Reservoir at Morrison Dam for the period 1981-90.

and 29 illustrate the increasing concentrations for TDS, boron, and sulphates, respectively.

To alleviate the elevated water table south of the reservoir and the attendant soil salinity concerns, Sask Power undertook a soil salinity project south of Morrison Dam. With the intent to lower the water table to pre-reservoir levels, wells were installed in a reach approximately 2.5 km below the dam. Phase 1 involved the installation of four wells on the east side of the River in 1989 and in 1990 four wells were placed on the west side as Phase 2. Discharge is returned to the reservoir through a common line. Three wells on the east side were operated during 1990 and pump testing for the west side wells was initiated in late 1990.

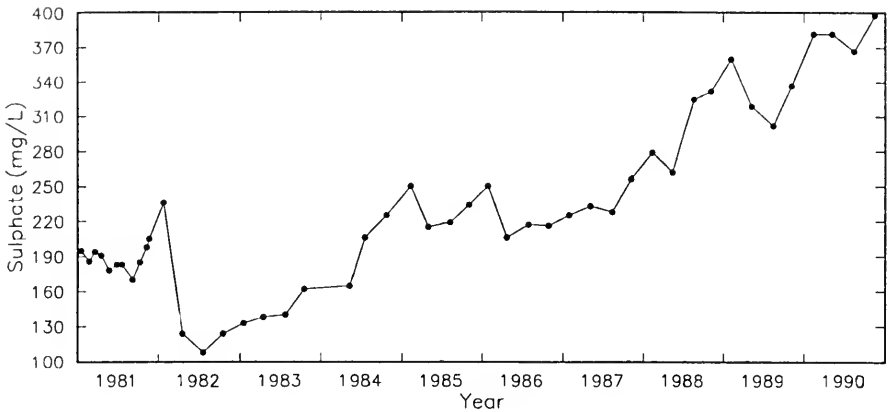


Figure 29.--Sulphate concentrations in Cookson Reservoir at Morrison Dam for the period 1981-90.

Return groundwater quality and volumes were measured. From startup in September, 1989, through December 1990, the total pumpage was approximately 896 dam^3 - less than 5% of the 1990 reservoir volumes. Water quality measurements have indicated slightly lower concentrations of total dissolved solids and boron than were present in the reservoir.

In 1990, Sask Power assumed responsibility for the regional dewatering system west of Coronach. Pumped volumes to Girard Creek and water quality measurements immediately downstream of the majority of pump wells were obtained. During 1990, this supplementary water supply provided approximately 4,693 dam^3, less than 20% of the 1990 Reservoir volume. The water quality is characterized by lower total dissolved salts and

boron concentrations (means of 943 and 1.28 mg/L respectively) than in Cookson Reservoir.

Quality Control

Quality control sampling was carried out at the East Poplar River at the International Boundary on September 13, 1990. Participating agencies included the United States Geological Survey, Environment Canada, Saskatchewan Environment and Public Safety and Sask Power.

Sets of triplicate samples were split from USGS sampling churns and submitted to the respective agency laboratories for analyses. Field procedures were identical to those used to 1986, 1987, 1988, and 1989.

The results were subsequently distributed to all participants for review by both field and analytical personnel. Most parameters showed good reproducibility. Results for total Kjeldahl nitrogen, dissolved iron and total molybdenum are not comparable. For total phosphorus, TDS and total chromium, one set of results is noticeably high compared to the other reported sets. Similarly, one of the reported data sets is low for silica and dissolved aluminum. The results reported by one agency for magnesium showed unacceptable variability. The USGS and Saskatchewan Environment and Public Safety's relatively high detection limits for nitrate/nitrite make it difficult to evaluate the results for these parameters.

Environment Canada will do a more detailed evaluation of all of the available historical data for this comparative quality control exercise and report to the Committee in early 1992.

GROUND WATER QUANTITY

Saskatchewan

Cookson Reservoir Supplementary Supply

On January 1, 1990, Sask Power took over responsibility for the network of coal mine dewatering wells south and west of Coronach. Sask Power assumed this responsibility for the purpose of using the network to supplement surface flows into Cookson Reservoir. Previously, this network had been operated and maintained by Prairie Coal for the purpose of dewatering the Hart coal seam to allow mining.

Most wells were in poor state of repair when taken over by Sask Power. Therefore, during the summer of 1990, approximately 25 wells were repaired and used as pump wells in 1990, with ten discharge points being used. In addition, five piezometers were replaced and five new piezometers were constructed.

Sask Power informed Saskatchewan Water Corporation that previous discharge volume measurements were possibly 30 to 50 percent in error. Saskatchewan Water Corporation and Sask Power were in agreement that this deficiency must be addressed. In order to more accurately determine pumped volumes, flow meters were installed in 1990 to verify flow volumes. Accurate quantification will greatly assist in long term decisions on aquifer yield.

Table 6 shows that groundwater pumpage from the well network peaked in the early to mid-1980's followed by continuing decrease in pumping in 1986 to 1989. This trend was reversed in 1990 with total abstraction for

the supplementary supply reaching 4,693 dam^3 (3,804 acre/ft). This rate of abstraction is expected to be maintained through 1991. The return to higher abstraction rates reflected the well network's new role as a supplementary supply during an extended period of drought and low surface runoff. Saskatchewan Water Corporation had granted Sask Power a temporary allocation of 5,000 dam^3 for 1990 and an additional 5,000 dam^3 for 1991. A summary of the monthly pumpages from all supplementary supply wells is shown in Table 7.

Table 6.--*Yearly abstraction of ground water for supplementary supply to Cookson Reservoir.*

Year	Volume (dam^3)	Volume (acre/ft)
Pre-1980	11,351	9,202
1980	4,064	3,295
1981	5,696	4,618
1982	5,993	4,858
1983	8,348	6,765
1984	7,764	6,294
1985	7,083	5,742
1986	5,032	4,080
1987	5,532	4,485
1988	3,492	2,831
1989	2,078	1,685
1990	4,693	3,804

Pumping was initiated in 1976.

Table 7.--*1990 monthly pumpage for supplementary supply to Cookson Reservoir.*

Month	Pumps working	Average flow (m^3/h)	Volume (m^3)	Y.T.D. (dam^3)
January	11	390.26	270,560	270.56
February	11	379.31	254,896	525.45
March	9	379.31	279,677	805.13
April	9	369.73	258,021	1,063.1
May	9	369.73	275,079	1,338.2
June	16	681.76	269,009	1,607.24
July	16	681.76	435,137	2,042.38
August	17	759.15	491,793	2,534.17
September	11	759.15	487,491	3,021.66
October	21	759.15	562,623	3,584.28
November	21	759.15	546,588	4,130.87
December	21	759.15	562,066	4,692.94

Sask Power has assumed the responsibilities for compiling and submitting drawdown maps for the Hart Coal Seam. Figure 30 shows the drawdowns as of December 1990 while, for comparative purposes Figure 31 shows the 1988 drawdowns. The one metre drawdown contour has not significantly advanced in the past year, and currently is approximately 1.8 kilometers from the International Boundary. Piezometers south of the border have begun to show drawdown effects of approximately 0.3 metres. This is most likely a function of continued pumping for the supplementary supply. However, some water level decreases may be attributed to a continuation of the drought. These drawdown effects will require close monitoring.

Comparison of Figures 30 and 31 indicates that the drawdown is continuing to expand in a northwesterly direction towards Fife Lake. The one metre drawdown appears to have reached the vicinity of Fife Lake, but the monitoring network is presently inadequate to accurately delineate the contour. The magnitude of the drawdown in the area of Fife Lake should

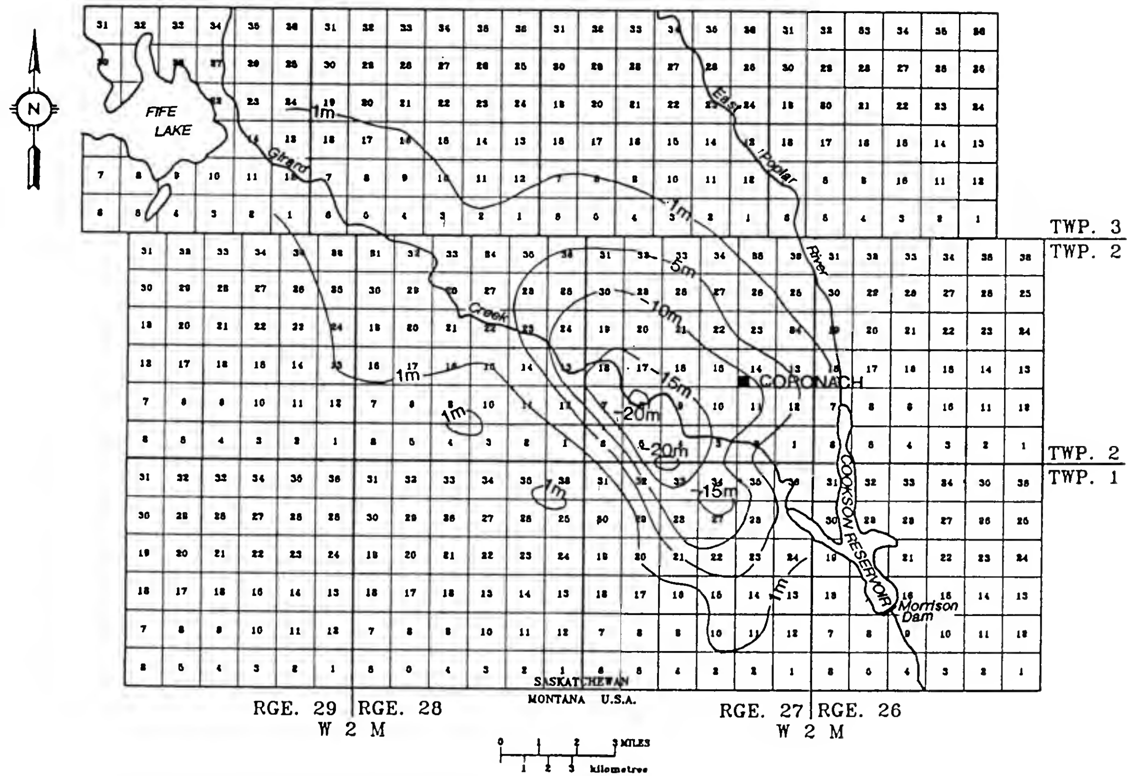


Figure 30.--Cone of depression in the Hart Coal Seam from dewatering activities as of December 1990. Contour intervals in metres.

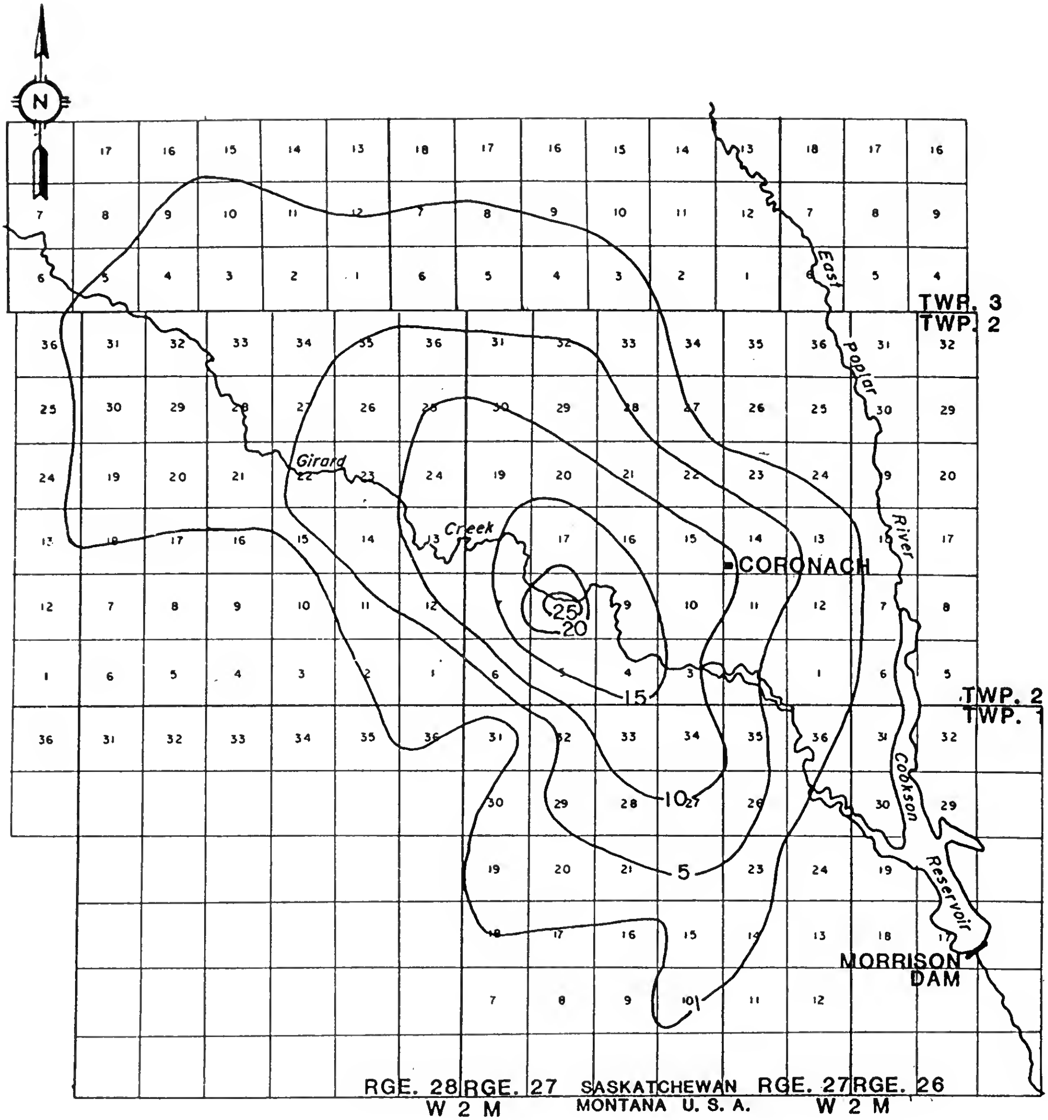


Figure 31.--Cone of depression in the Hart Coal Seam from dewatering activities of 1988. Contour interval in meters.

not be enough to have significant impacts on residents. Nonetheless, well inventories and the monitoring network may have to be extended in the area. In addition, possible interactions with Fife Lake may have to be addressed. There also seems to have been minor expansion of the cone of depression easterly towards Cookson Reservoir.

In order to obtain additional knowledge of the area, Sask Power has undertaken a groundwater modeling study for the supplementary supply. It is hoped that this study will provide additional information on the yield of the aquifer and possible impacts on the International Boundary and the area northwest of the supplementary supply wells.

Salinity Dewatering Project

A second groundwater project is being undertaken by Sask Power near Cookson Reservoir. This is a dewatering project which is intended to reduce a salinity build-up that appears to have resulted from an increase in the water table below the dam following the filling of the reservoir.

The project went into operation in the fall of 1989, with three wells in operation. A total of 131 dam^3 (106 acre/ft) was pumped from the three wells in 1989. During the fall of 1990, an additional 4 wells were installed and one was put into operation. Total pumpage from all salinity project wells for 1990 was 706 dam^3 (572 acre/ft). Table 8 shows monthly pumpages for 1990 from each well. Van der Kamp and Maathuis (1989) concluded that dewatering rates up to 1,100 dam^3/year (890 acre/ft/year) are possible.

Table 8.--*Poplar River Power Station salinity project 1990 monthly pumpage volumes*

[cubic metres]

Month	PW87102	PW87103	PW87104	PW90106	PW90108
January	10,290	17,693	36,065	0	0
February	13,306	18,144	33,143	0	0
March	14,999	21,159	36,158	0	0
April	8,297	20,607	36,867	0	0
May	2,215	16,840	24,659	0	0
June	5,835	21,318	32,695	0	0
July	3,927	16,749	30,205	0	0
August	2,924	17,590	32,384	0	0
September	5,062	21,155	38,141	0	0
October	3,835	16,892	18,664	0	0
November	3,524	18,255	30,888	0	20,528
December	4,817	22,430	27,696	5,302	33,504
Total volume pumped to date	79,031	228,932	398,565	5,302	54,032
Total	705,528 m^3 (572 acre-ft)				

Van der Kamp and Maathuis (1989) concluded that a lowering of water levels by 1 to 3 metres would be possible. This would roughly correspond to pre-reservoir levels. Figure 32 shows the development of two meter drawdown contours around PW87102, PW87103, and PW90108 and demonstrates that the project has shown a reasonable degree of success. Pumping from PW90106 should begin to increase drawdowns on the northwest side of the river. The 1.0 metre drawdown is approximately 1 kilometre north of the International Boundary, while the 0.5 metre drawdown crosses the boundary.

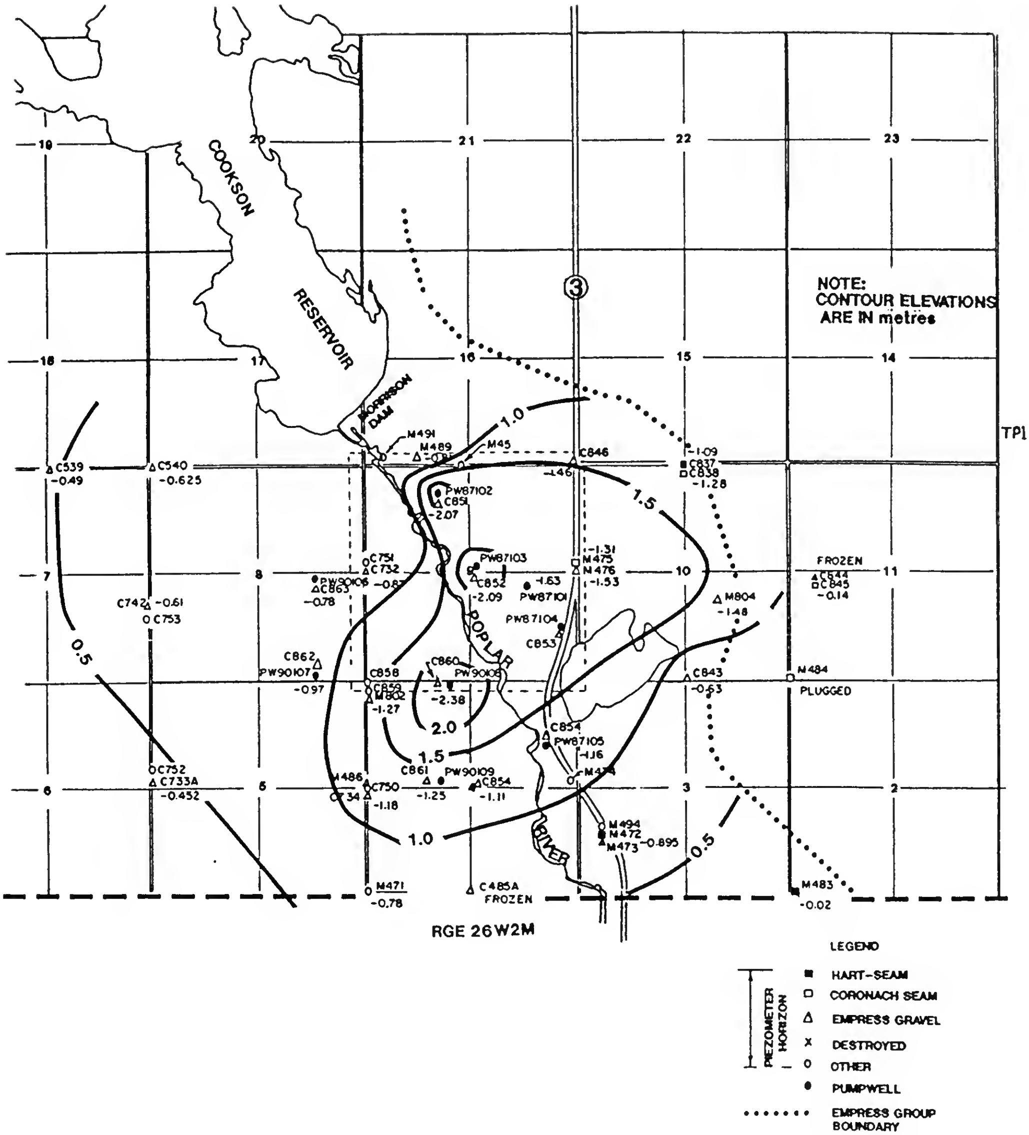


Figure 32.--Cone of depression in Empress aquifer from dewatering activities of salinity project as of December 1990. Contour in metres.

Montana

The Montana groundwater monitoring program consisted of 10 wells (GWQQC 2-11) from 1978 until 1984, when 11 additional wells (GWQQC 12-22) were installed. Well 4 was dropped from the schedule in September 1990 when it was found plugged. In 1990, two additional wells were installed to monitor effects of pumping the Empress Gravels for salinity control.

Hydrographs reflecting water level measurements for selected wells completed in the Hart coal are presented in Figure 33, and measurements along with recorder readings for other wells are presented in Figure 34.

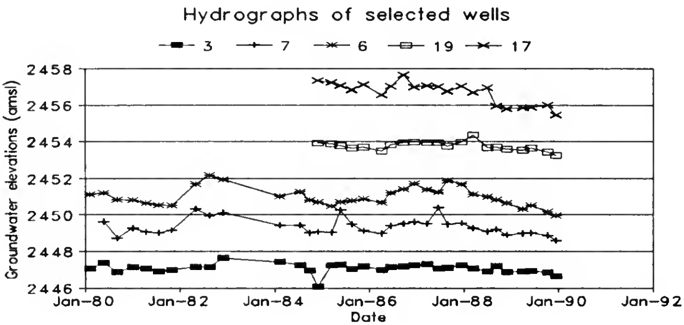


Figure 33.--Hydrographs for selected coal wells completed in Hart Coal Bed.

Beginning in 1987 and 1988, trends of water-level decline have developed in several wells. Water levels in wells completed in the Hart coal bed have declined approximately 1 foot thus far, the apparent greatest decline (well 6) occurring at the International Boundary south of Cookson Reservoir. Wells 5 and 10, also located at the border and completed in unconsolidated beds, show variable water-levels. The variability is probably attributable to the pumping associated with salinity control pumpage below Cookson Reservoir.

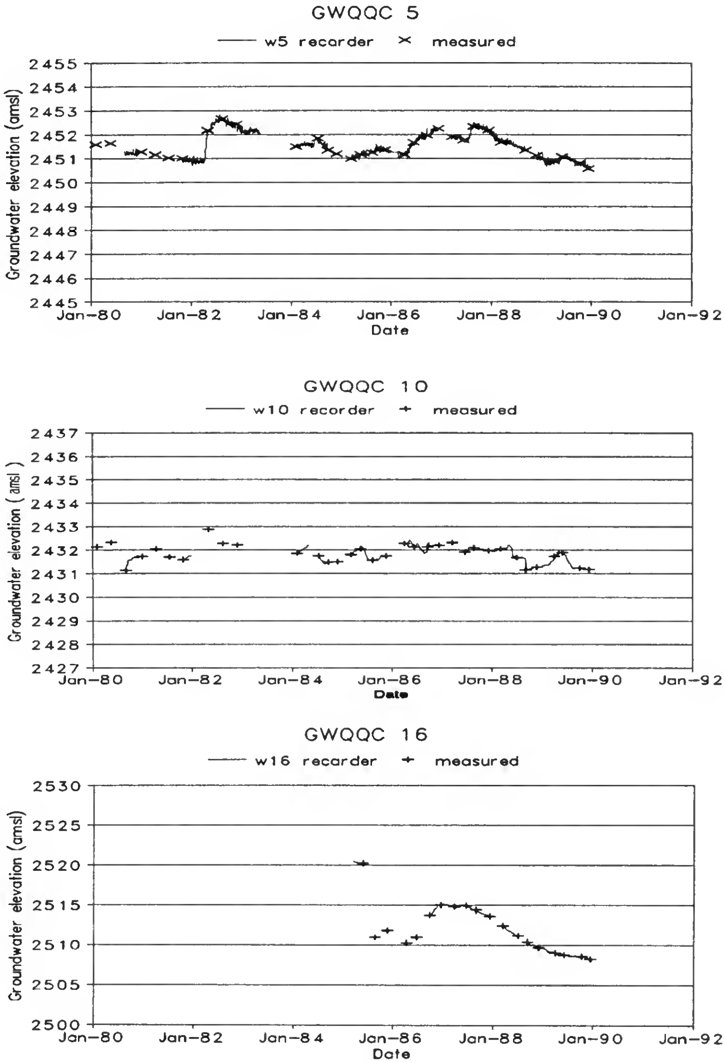


Figure 34.--Hydrographs for GWQQC 5, GWQQC 10 nd GWQQC 16.

A water-level decline in well 16, located to the west in the Middle Fork of the Poplar drainage, of approximately 5 feet is not explainable at this time.

Other wells being monitored (4, 8, 9, 11 and 18) which includes two in the Fox Hills-Hell Creek aquifer, have shown no trends in water-level change.

GROUND WATER QUALITY

Saskatchewan

Ground water sampling continued in 1990 at the locations specified in the Technical Monitoring Schedule. The ground water quality and water levels were compared to historical data for each of the piezometers in the 1990 Monitoring Schedule.

A number of graphs are presented for total dissolved solids, chloride, boron, and water level measurements to illustrate the results of monitoring to date. Chloride was selected because it is a conservative constituent in ground water systems and boron because it is a significant contaminant in the ash lagoon waters. A statistical trend analysis was performed on selected parameters. The following discussion of ground water quality is organized by piezometer locations relevant to the ash lagoon.

West Side of Lagoon

Location 8a (West of Cell #1)

Piezometers, C726A and C726C are completed in the till. There have been no significant water quality changes in these piezometers. A plot of

total dissolved solids (TDS)-vs-time is shown in Figure 35 for these piezometers. Piezometer C726E, in the Empress Gravels, shows no significant water quality changes. TDS-vs-time is plotted for this piezometer in Figure 36. Water levels have decreased in C726E as shown in Figure 37. This is consistent with water level results for piezometers in the Empress Gravels at other locations.

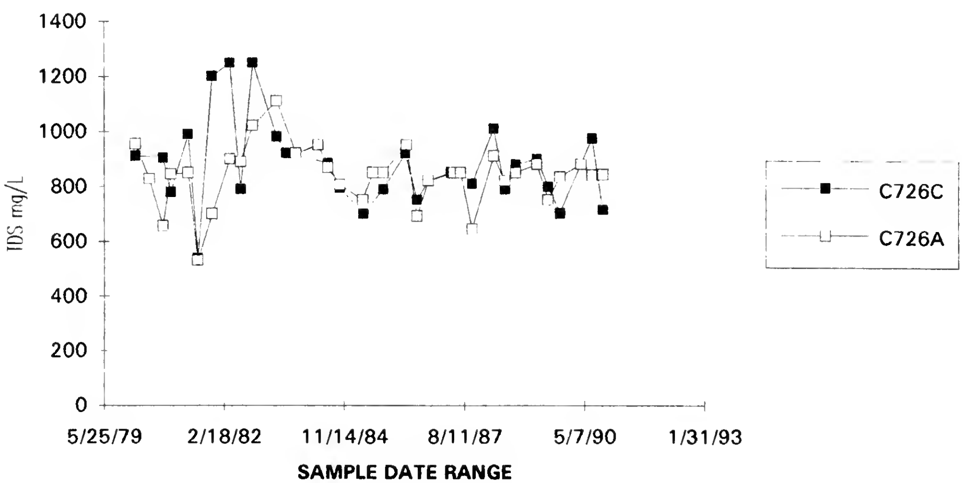


Figure 35.--TDS in till piezometers C726A and C726C.

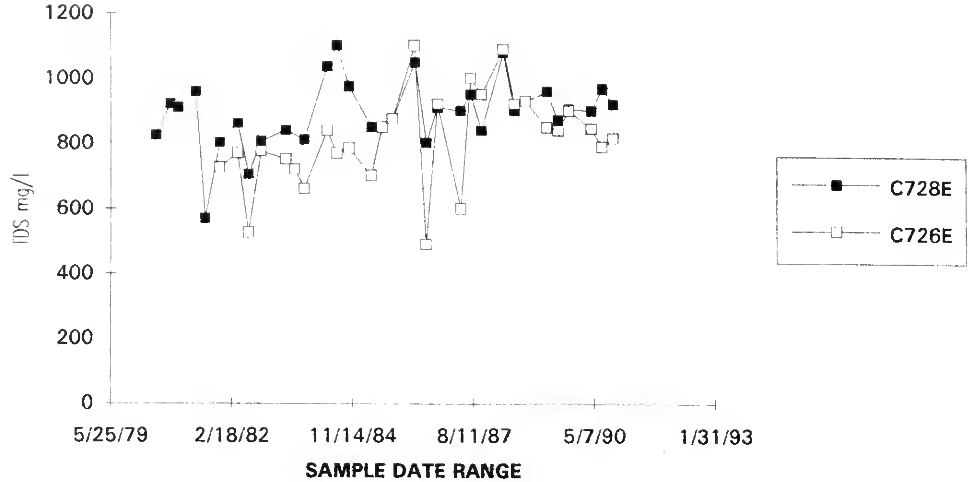


Figure 36.--TDS in Empress piezometers C726E and C728E.

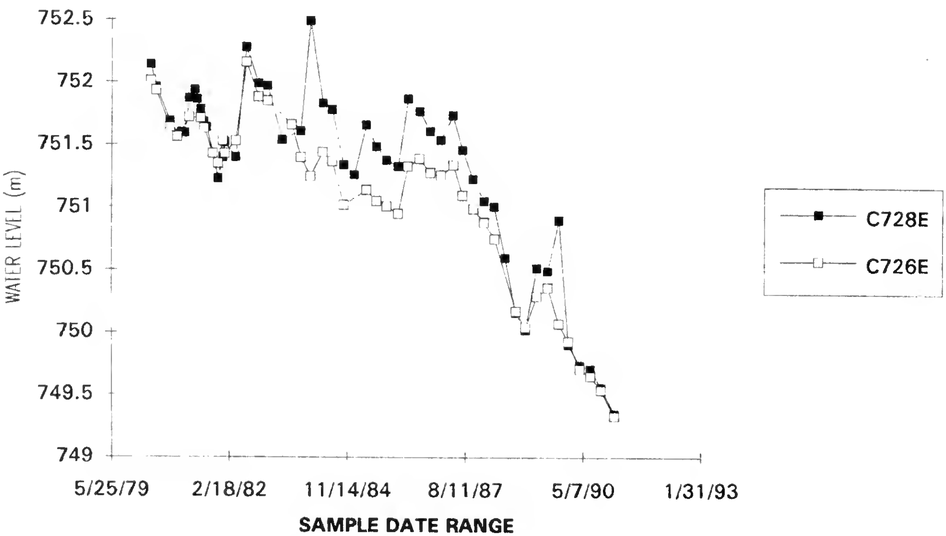


Figure 37.--Water levels in Empress piezometers C726E and C728E.

<u>Location 9a (West of the Polishing Pond)</u>

Piezometers C728A, C728B, C728C, and C728D are in the till. Piezometers C728A and C728D, in the oxidized till, have been monitored for water quality since April, 1986. TDS levels have been steady for C728A and indicate an increasing trend for C728D as shown in Figure 38. The results are elevated compared to the till piezometers at location 8a. Chloride (Cl) results have decreased for C728A, and C728D indicates an increasing trend as shown in Figure 39. Boron (B) results have been steady for both of these piezometers as shown in Figure 40. Water levels for these piezometers seem to be stabilized after a significant increase for a number of years as shown in Figure 41.

Piezometer C728C is in the mottled till and C728B is in the unoxidized till. C728C indicates a slight increase for TDS in Figure 38. C728B shows a steady trend for TDS in Figure 38. Cl results have been steady for C728B and slight increasing trend for C728C as shown in Figure 39. B results are steady for both piezometers as shown in Figure 40. Uranium concentrations increased in C728C in 1984. However, results since 1984 are typical of piezometers completed in the mottled till. Water levels are increased for C728C and have been steady for C728B as shown in Figure 41.

Piezometer C728E is in the Empress Gravels. TDS have been variable with no trends as shown in Figure 36. The results are similar to TDS for C726E in the Empress Gravels at location 8a. Other water quality parameters for C728E have shown no consistent changes. Water levels for C728E have been decreasing as shown in Figure 37.

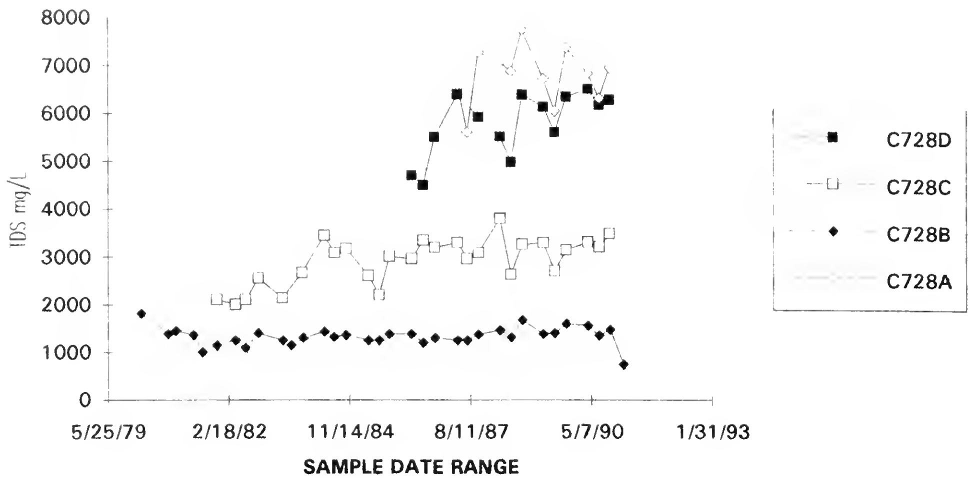


Figure 38.--TDS in till piezometers C728A, C728B, C728C, and C728D.

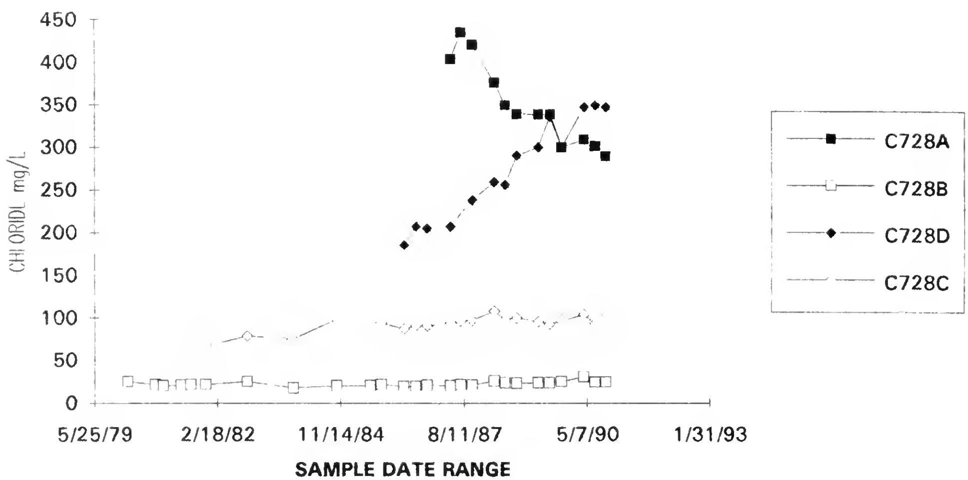


Figure 39.--Chloride in till piezometers C728A, C728B, C728C, and C728D.

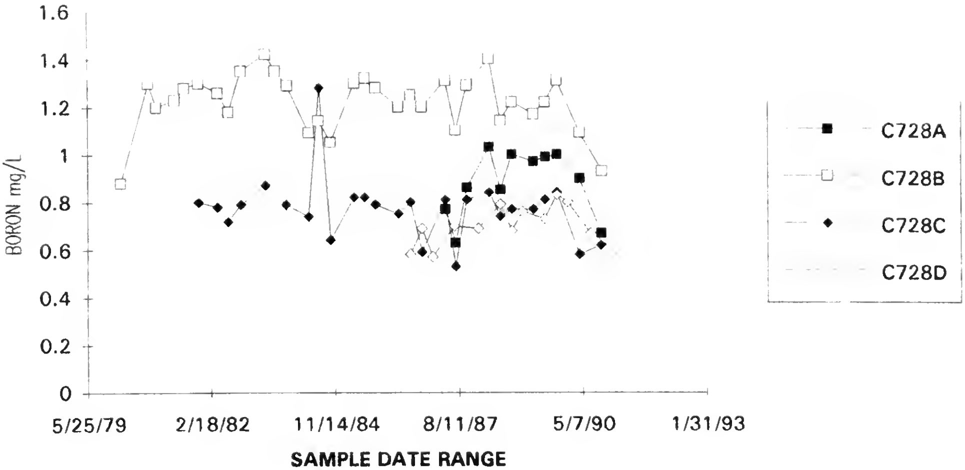


Figure 40.--Boron in till piezometers C728A, C728B, C728C, and C728D.

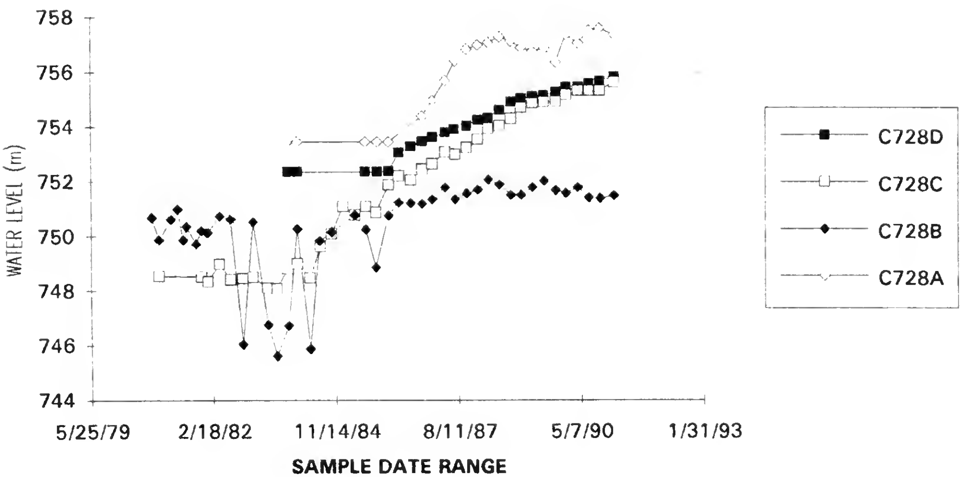


Figure 41.--Water levels in till piezometers C728A, C728B, C728C, and C728D.

North Side of Lagoon

Location 2a (North of the Polishing Pond)

Piezometer C712B which is in the intra till sand, shows increasing B levels in Figure 42. TDS results have gradually decreased after significantly increasing from 1980 to 1983 as shown in Figure 43. Cl levels show a decreasing trend in Figure 44. The sample result for zinc (Zn) in 1990 decreased to concentrations obtained in 1986 and 1987 as shown in Figure 45. Water levels have been steady as indicated in Figure 46.

A review of the leachate movement at piezometer C712B was done during the leachate review of the ash lagoons conducted by Clifton Associated Ltd. for Sask Power. The leachate review was combined with the seepage calculation review and forwarded to the Poplar River Bilateral Monitoring Committee members for comments. The leachate review noted that a slug of leachate is probably affecting the sand lens piezometers.

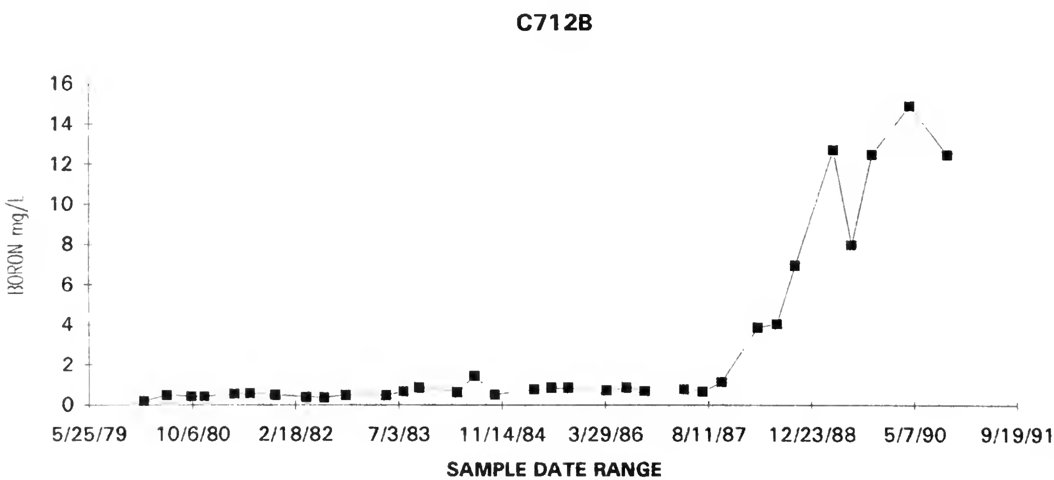


Figure 42.--Boron in intra-till sand piezometer C712B.

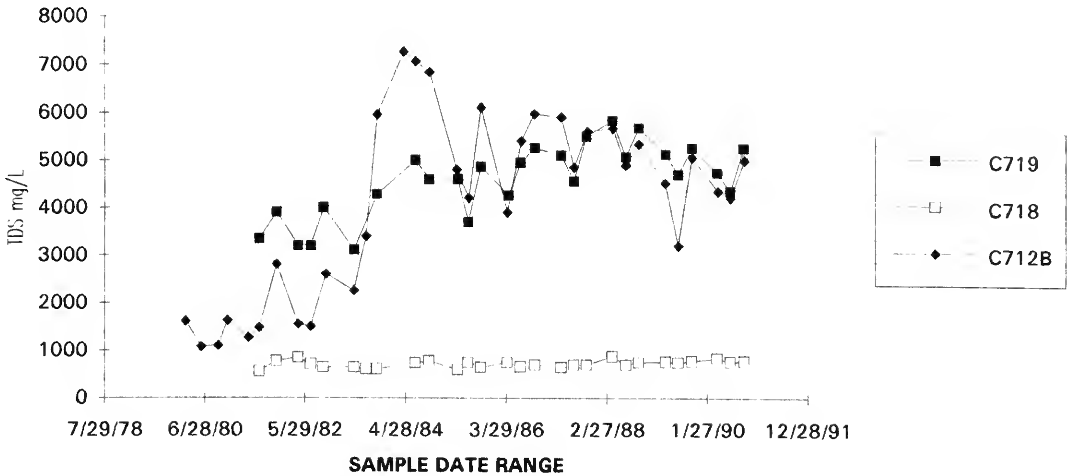


Figure 43.--TDS in piezometer C712B and till piezometers C718 and C719.

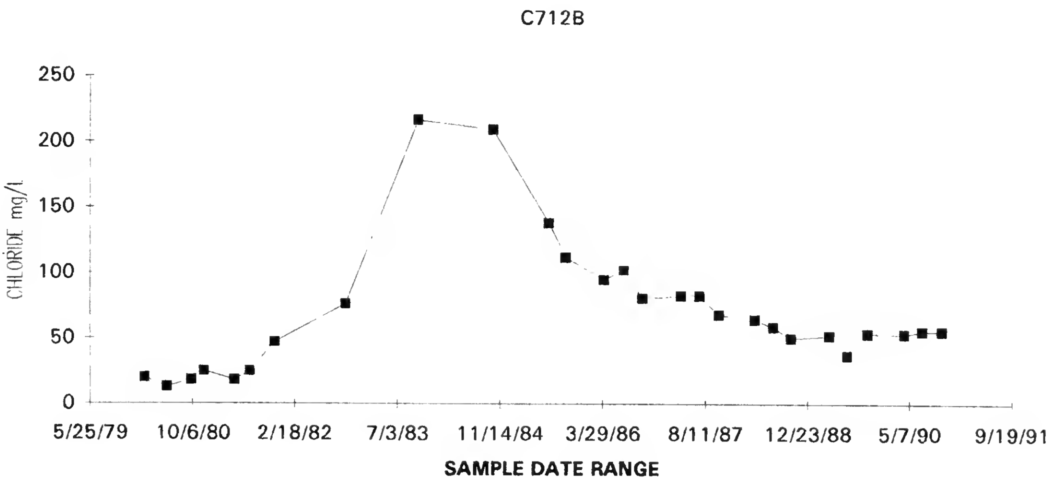


Figure 44.--Chloride in piezometer C712B.

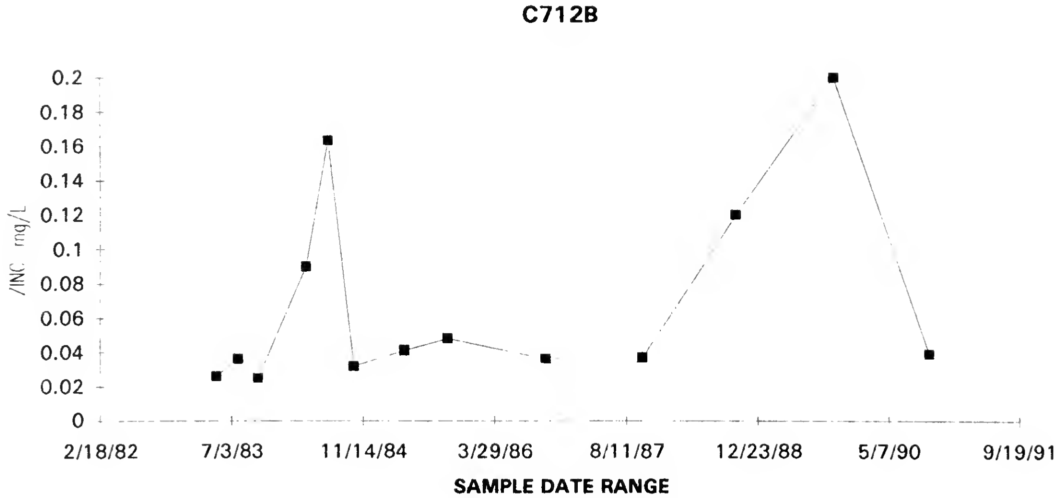


Figure 45.--Zinc in piezometer C712B.

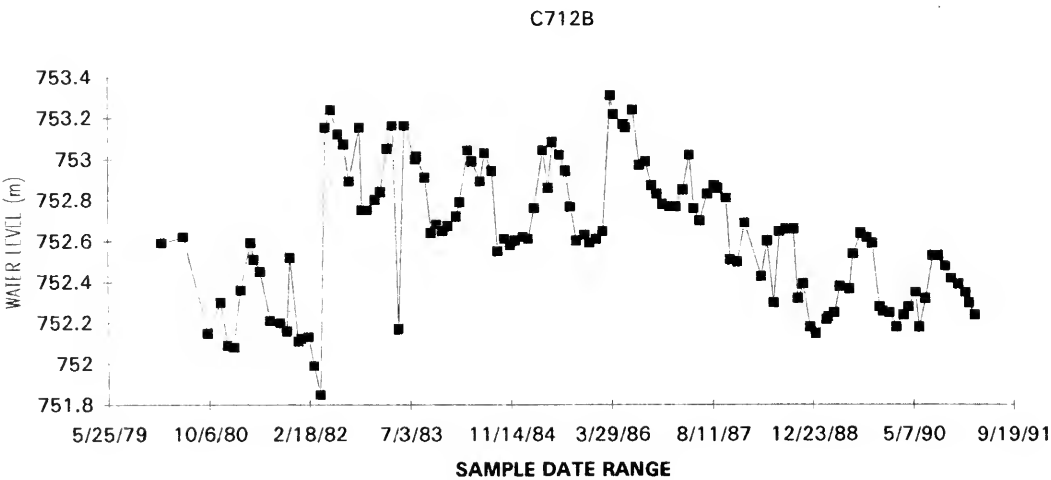


Figure 46.--Water levels in piezometer C712B.

Locations 2b and 2c (north of the Polishing Pond)

Piezometer C718 and C719 at location 2b and 2c, respectively, are in the till. TDS have increased slightly in C719 and have been steady in C718. Cl results have been decreasing in C719 and steady in C718 as indicated in Figure 47. C719 has shown an increasing trend for sulphates and also an increase in uranium results until 1985 with a steady trend since then.

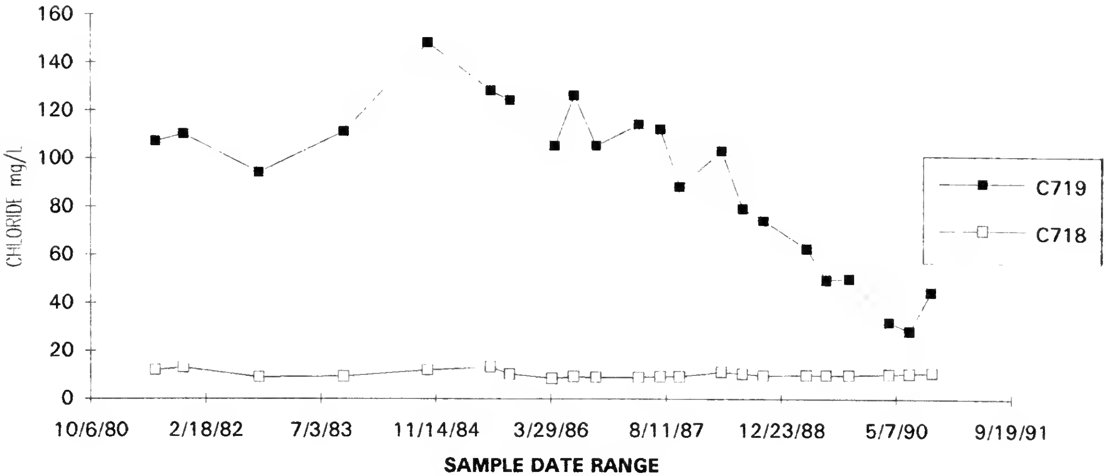


Figure 47.--Chloride in till piezometers C718 and C719.

Locations 24, 25, and 26 (North of Cell 3)

Piezometers C714A and C714D in the till are at locations 24 and 25 respectively. TDS have increased in C714A and have been steady in C714D as shown in Figure 48. Other water quality parameters have shown no consistent changes.

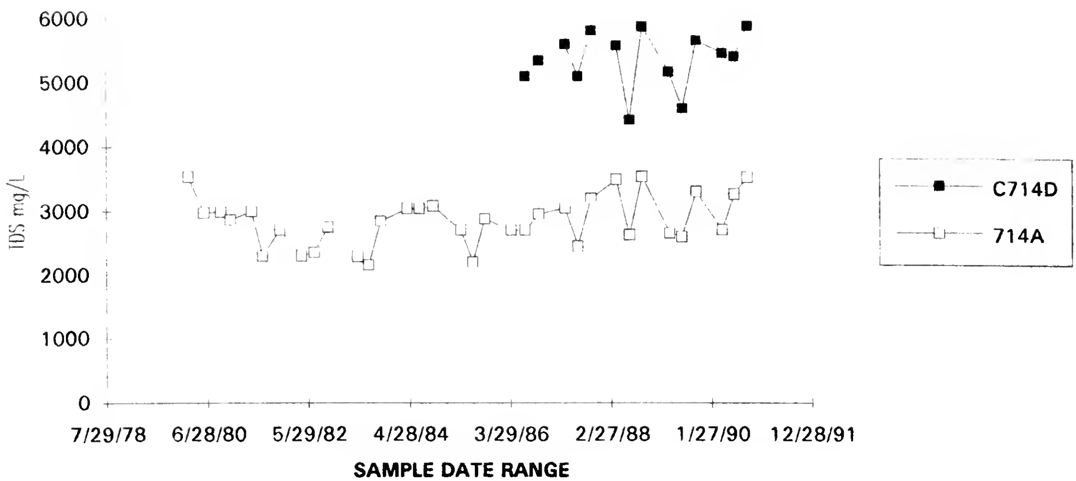


Figure 48.--TDS in till piezometers C714A and C714D.

Piezometer C714E in the Empress Gravels is at location 26. TDS have been steady as shown in Figure 49 with a slightly lower-than-normal concentration compared to the Empress piezometers.

South Side of Lagoon

Locations 22 and 23 (South of Cell #1)

Piezometer C533 is in the Empress Gravels at Location 22 and piezometer C534 is in the till at location 23. TDS have not shown any trends to lower or higher concentrations as indicated in Figure 50. TDS have fluctuated over a wide range for C534 with values similar to other till piezometers. Cl and B results have shown no significant trends.

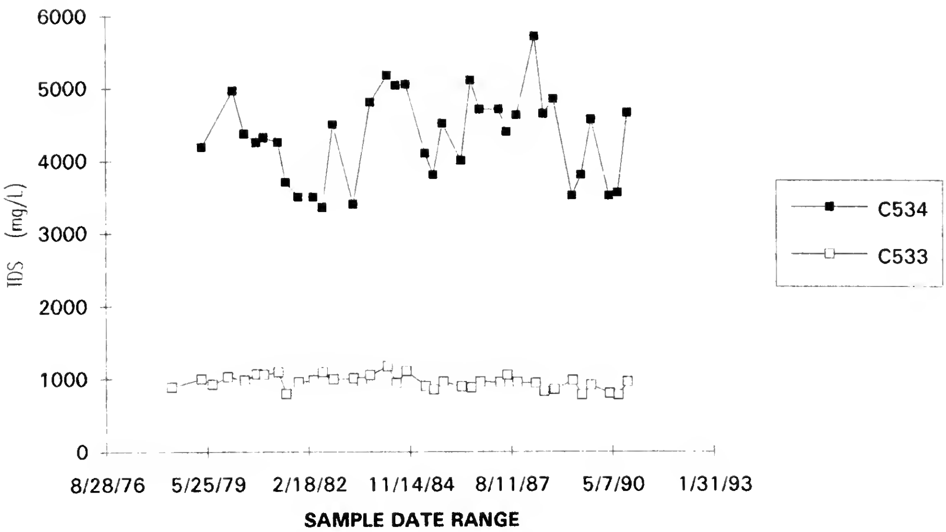


Figure 49.--TDS is Empress piezometer C714E.

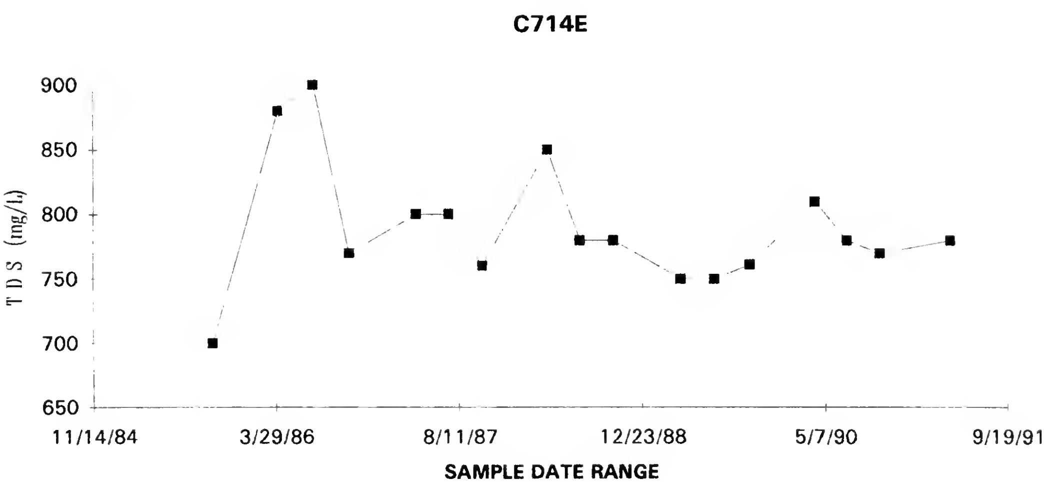


Figure 50.--TDS in Empress piezometer C533 and till piezometer C534.

Locations 26, 27, and 28 (South of Cell #3)

Piezometer C774B is in the oxidized till at location 26 and piezometer C775A is in the oxidized till at location 27. TDS have shown no consistent changes for these piezometers as noted in Figure 51. B concentrations have appeared to decrease with time for C775A as show in Figure 52. Cl concentrations as indicated in Figure 53 for both piezometers, have been steady.

Piezometer 775D is in the Empress Gravels at location 28. TDS, as shown in Figure 54, have been steady since 1987 after a significant increase from 1985 and 1986 results. Cl shows trends similar to TDS as noted in Figure 55. B results seem to be decreasing slightly as shown in Figure 56. Other water quality parameters show no significant changes.

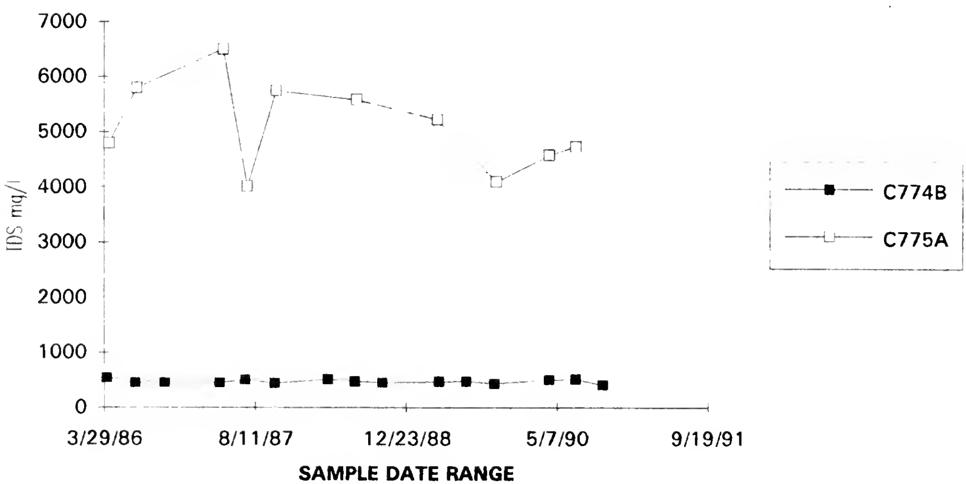


Figure 51.--TDS in till piezometers C774B and C775A.

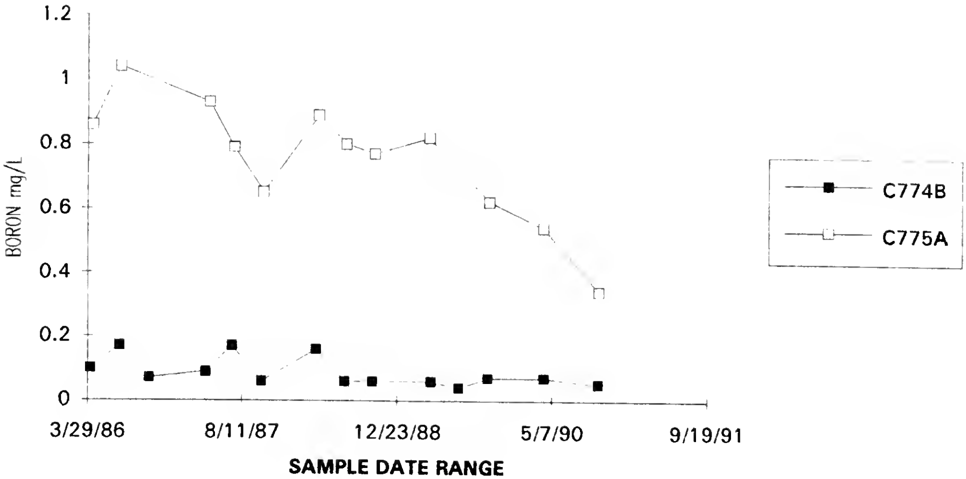


Figure 52.--Boron in till piezometers C774B and C775A.

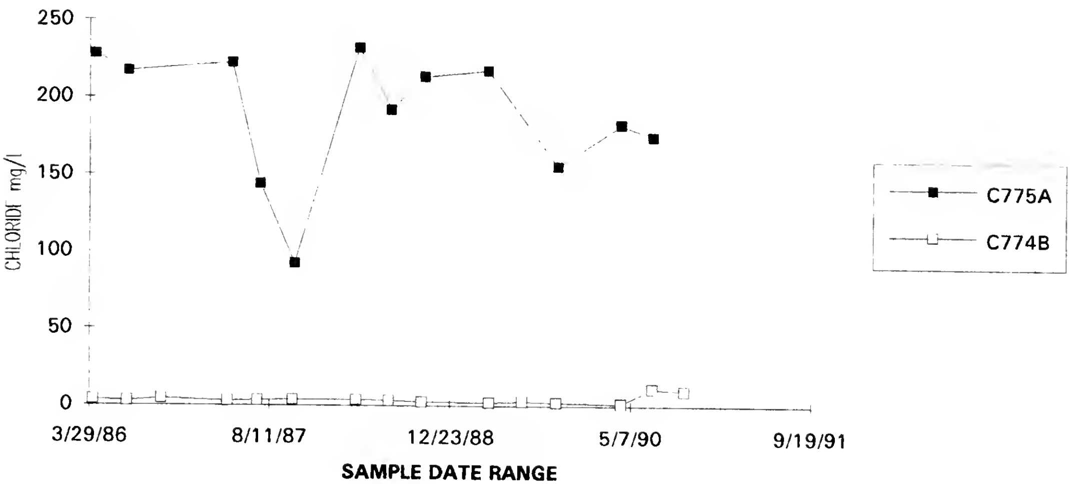


Figure 53.--Chloride in till piezometers C774B and C775A.

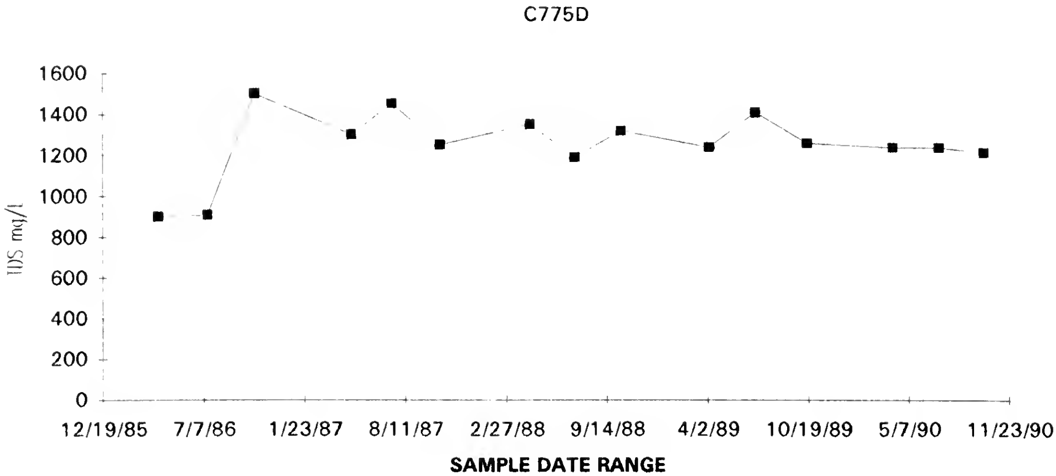


Figure 54.--TDS in Empress piezometer C775D.

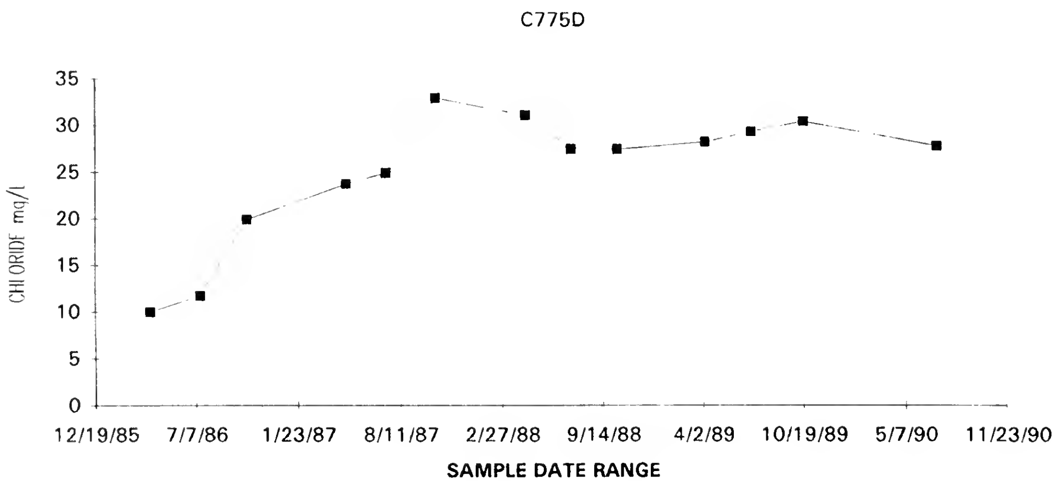


Figure 55.--Chloride in Empress piezometer C775D.

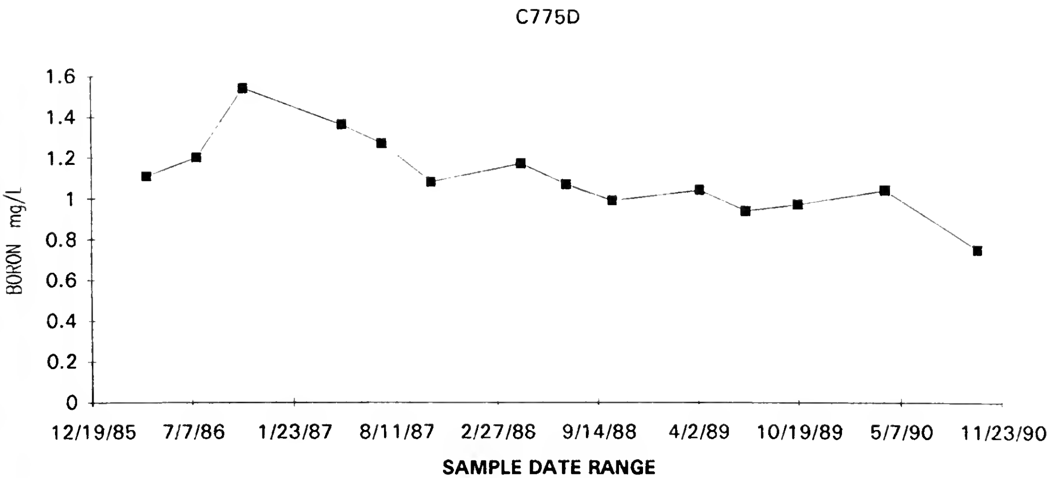


Figure 56.--Boron in Empress piezometer C775D.

Southwest of Morrison Dam

<u>Locations 18 and 21</u>

Piezometers C741 and C742 are in the Empress Gravels at locations 18 and 21, respectively. TDS as shown in Figure 57, have not indicated any significant changes since the higher values in 1983-84. There are no significant trends for other water quality parameters for these piezometers. Water levels for these piezometers as shown in Figure 58, are decreasing since 1986 similar to other Empress Gravel piezometers.

Overall TDS and Cl concentrations are higher and more variable in the till than the Empress Gravels. However, B concentrations are typically higher in the Empress Gravels than the till.

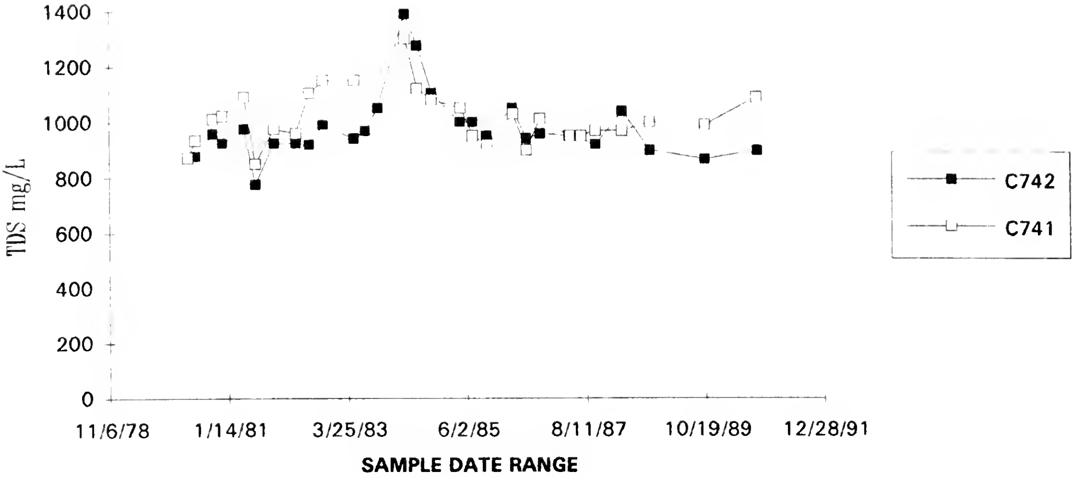


Figure 57.--TDS in Empress piezometers C741 and C742.

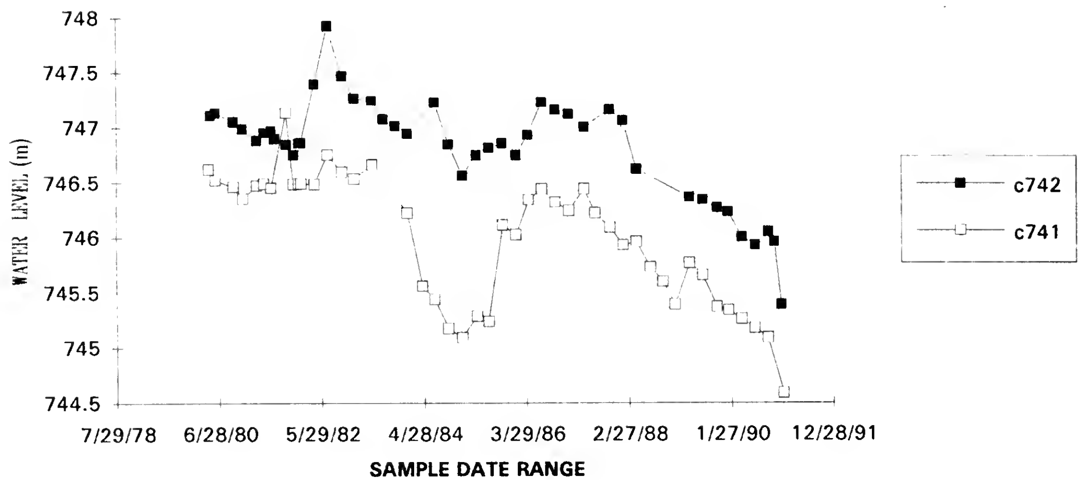


Figure 58.--Water levels in Empress piezometers C741 and C742.

Montana

Groundwater from the different sources has unique water quality characteristics as illustrated by Figure 59. Water in the Fox Hills-Hell Creek (Frenchman-Whitemud-Eastend) regional aquifer has characteristics typical of those for the rest of the region. The water has undergone cation exchange and sulfate reduction, leaving very low concentrations of calcium, magnesium, and sulfate. The chloride concentrations are higher than those occurring in eastern Montana but are not atypicial for this locale (Montana Groundwater Information Center data, Butte). Predominant constituents are therefore sodium, chloride, and bicarbonate.

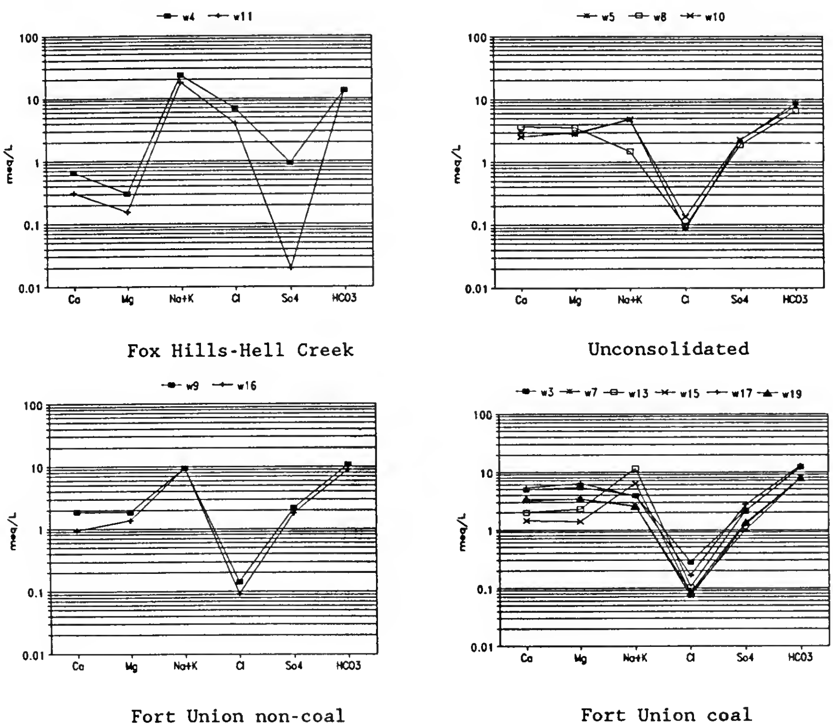


Figure 59.--Concentrations of major ions in milliequivalents per liter in water from four major aquifers.

High concentrations of sodium and bicarbonate also occur in the Fort Union (Ravenscrag) Formation but chloride concentrations are substantially lower than those in the Fox Hills-Hell Creek aquifer. Most of the Hart coal wells in the Fort Union Formation have higher concentrations of calcium and magnesium than sodium, but water quality in a localized group of wells (13 and 15) resembles that of other Fort Union beds suggesting hydraulic continuity between the coal and non-coal aquifers.

Water quality of the shallow unconsolidated deposits resembles that of the Fort Union, suggesting a common flow system for these units.

Sampling for water quality was performed annually on wells listed in the quantity section until 1989, when the schedule was reduced to wells 5-11 13, 15, and 19.

There has been little variability over time in the toal dissolved solids at selected wells as indicated in Figure 60.

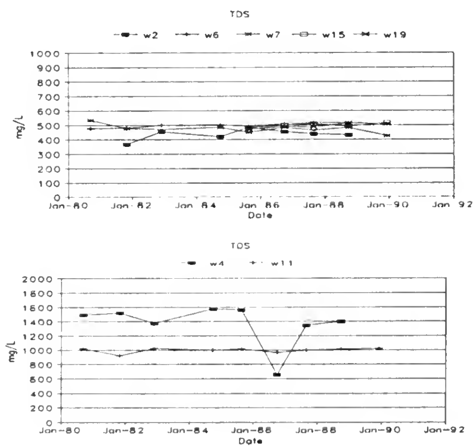


Figure 60.--Total dissolved solids concentrations for water from selected wells during the period of sampling.

The concentrations show no significant trends over the period of record. A change from an average of 1,500 mg/L to 660 mg/L was observed for well 4 in 1986. The casing was found broken at ground surface allowing surface water to enter the well. The 1.5 inch diameter casing makes purging difficult. This well has been dropped from the sampling schedule.

ASH LAGOON QUALITY AND QUANTITY

The ash lagoon system at the Poplar River Power Station continues to be operated on a closed system basis with no discharge to surface waters. During 1990, an estimated 577,800 m^3 of ash was deposited to the ash lagoons. Approximately 346,700 m^3 of water was used for sluicing. The sluiced ash was usually directed to the west or east side of Ash Lagoon No. 1 or the southeast corner of Ash Lagoon No. 3. Occasionally, sluiced ash was directed to the west side of Ash Lagoon No. 2. When ash is directed to Ash Lagoon No. 1, the normal series operation is Ash Lagoon No. 1, Ash Lagoon No. 2, and the Polishing Pond. When ash is directed to Ash Lagoon No. 3, water from that lagoon is pumped to Ash Lagoon No. 2 where it flows by gravity to the Polishing Pond. When ash is directed to Ash Lagoon No. 2, water flows by gravity directly to the polishing pond. In all cases, water from the polishing pond is returned to the plant for sluicing.

During 1990, maximum and minimum water depths were 7.0 and 5.3 m in Ash Lagoon No. 1, 5.9 and 4.5 m in Ash Lagoon No. 2, 1.93 and 0.8 m in Ash Lagoon No. 3, and 4.1 and 1.7 in the polishing pond.

During 1990, approximately 3,200 metres of ash line was replaced. Most of the replaced pipe was heavier walled than the pipe that was originally installed. Where possible, the ash lines were placed inside the lagoon dykes so that any leaks would be contained within the lagoon system.

In November 1990, the ash dykes on Ash Lagoon No. 1 were built up to make room for future operations. The discharge structure was also modified accordingly.

Seepage calculation using the methods developed by T.A. Prickett, P.E., of Urbana, Illinois, were slightly modified in 1989 to address the loss of piezometer series C730 associated with Ash Lagoon No. 1. The same modifications which involve estimating data for C730 series piezometers were used in 1990. Also, as in 1989, piezometer level measurements were used rather than calculating the change in water levels per year. Results of the seepage calculations for Ash Lagoon No. 1, 2, and 3 and the polishing pond are shown in table 9. A graph of annual seepage rates is shown in Figure 61.

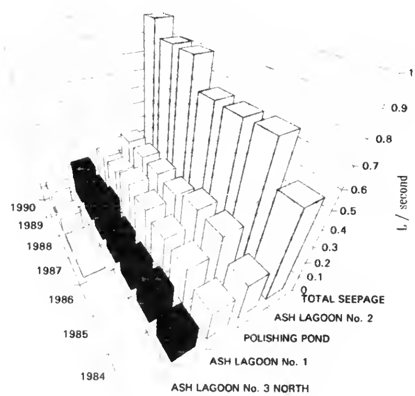


Figure 61.--Ash lagoon seepage rates at the Poplar River Power Station, 1984-1990.

Table 9.--*Ash lagoon seepage rates and liner permeabilities at the Poplar River Power Station, 1984-90*

	Liner Permeability (cm/s)	Seepage Rate Vertical (L/s)	Horizontal (L/s)	Total (L/s)
Polishing Pond				
1984 Oct.	8.13×10^{-9}	0.055	0.128	0.183
1985 Oct.	8.70×10^{-9}	0.064	0.175	0.239
1986 Oct.	10.8×10^{-9}	0.062	0.188	0.250
1987 Oct.	14.4×10^{-9}	0.078	0.200	0.278
1988 Oct.	28.7×10^{-9}	0.087	0.226	0.313
1989 Oct.	20.6×10^{-9}	0.066	0.214	0.280
1990 Oct.	18.6×10^{-9}	0.072	0.206	0.278
Ash Lagoon No. 1				
1984 Oct.	2.20×10^{-9}	0.075	0.068	0.143
1985 Oct.	3.66×10^{-9}	0.085	0.087	0.172
1986 Oct.	1.95×10^{-9}	0.083	0.070	0.153
1987 Oct.	2.36×10^{-9}	0.092	0.080	0.172
1988 Oct.	4.00×10^{-9}	0.121	0.125	0.246
1989 Oct.	2.88×10^{-9}	0.135	0.179	0.214
1990 Oct.	3.00×10^{-9}	0.160	0.076	0.236
Ash Lagoon No. 2				
1984 Oct.	3.8×10^{-9}	0.116	0.114	0.230
1985 Oct.	9.22×10^{-9}	0.189	0.15	0.339
1986 Oct.	10.5×10^{-9}	0.199	0.144	0.343
1987 Oct.	11.0×10^{-9}	0.219	0.080	0.299
1988 Oct.	16.0×10^{-9}	0.236	0.081	0.317
1989 Oct.	7.8×10^{-9}	0.250	0.073	0.323
1990 Oct.	6.6×10^{-9}	0.260	0.073	0.333
Ash Lagoon No. 3 North				
1987 Oct.	0.17×10^{-9}	0.002	0.0	0.002
1988 Oct.	[1]	0.022	0.0	0.022
1989 Oct.	11.8×10^{-9}	0.030	0.059	0.089
1990 Oct.	23.6×10^{-9}	0.042	0.102	0.144

Total Seepage

1984 - 0.556 (L/s)
1985 - 0.750 (L/s)
1986 - 0.746 (L/s)
1987 - 0.751 (L/s)
1988 - 0.898 (L/s)
1989 - 0.906 (L/s)
1990 - 0.991 (L/s)

[1] Permeability for Ash Lagoon No. 3 North could not be calculated because of negative gradients.

An extensive review of the seepage calculations has been completed by Sask Power. Several different methods were used to calculate estimated seepage rates and lagoon liner permeabilities. The seepage rate values obtained were higher but in the same order of magnitude as the seepage rates obtained by the existing method. While this confirms the existing method of seepage calculation, Sask Power still recommends proceeding with the adoption of an updated method following acquisition of additional piezometric information.

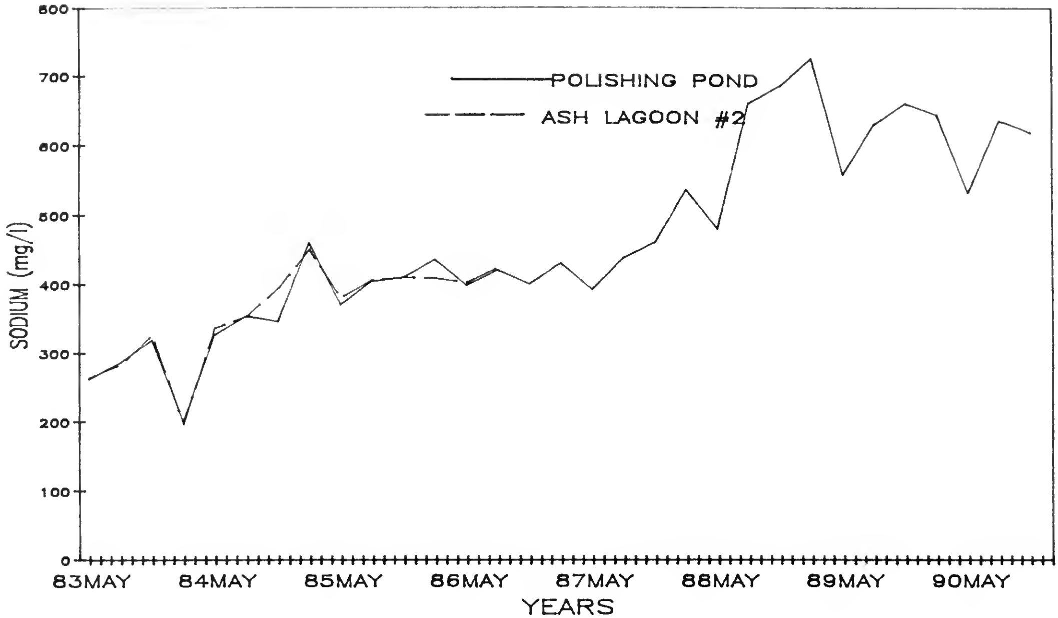
The Saskatchewan Department of Environment and Public Safety requires that Sask Power maintain the stability of the ash lagoon system dykes. In addition to the regular visual inspections, an annual investigation by a geotechnical engineer was conducted in October 1990. The geotechnical consultant indicated that the ash lagoon dykes and liners have good integrity and the ash is contained effectively. The consultant noted that the lagoon system is performing as designed. No special recommendations were made other than continued routine monitoring. The freeboard limits were not exceeded during 1990 for Ash Lagoon No. 2, Ash Lagoon No. 3, and the Polishing Pond. Freeboard limits were exceeded on Ash Lagoon No. 1 during 1990; however, the intent of the freeboard limit was no longer relevant due to the ash dykes within the clay dykes. The freeboard limit for Ash Lagoon No. 1 was removed from the new permit issued by Saskatchewan Environment and Public Safety in November 1990.

Sask Power continued to experiment with the surcharging of ash into the lagoons. A geotechnical review of the ash surcharging project was completed in 1990. The report indicates that slopes of 25 percent should pose no problems. The report also recommended that the ash stacks be

limited to 10 m in height without special ash stacking procedures. The experimental program which was started in 1978 to determine suitable types of vegetation for the exposed ash, continued in 1990. Three species of grass continued to show good results.

The water quality data continued to show slight increasing trends in sodium and molybdenum; however, a leveling trend for these parameters may be developing. Sulphate and fluoride concentrations have been fairly erratic but appear to be developing a slight decreasing trend. Chromium and strontium have both shown decreasing trends in recent years but now appear to be leveling off. Vanadium has historically been quite stable at fairly low levels but has decreased to below detection in 1990.

Uranium levels have historically been quite variable but have rarely exceeded detection (0.1 μg/L) in 1990. Considerably higher pH levels were noted in the ponds during 1990. This was accompanied by reduced boron values. Further testing in 1991 will provide more information on the pH and boron values. Generally, the quality variations of the filtered ash lagoon water are not unexpected in a closed system of this type. Ash lagoon water quality is shown in Figure 62.



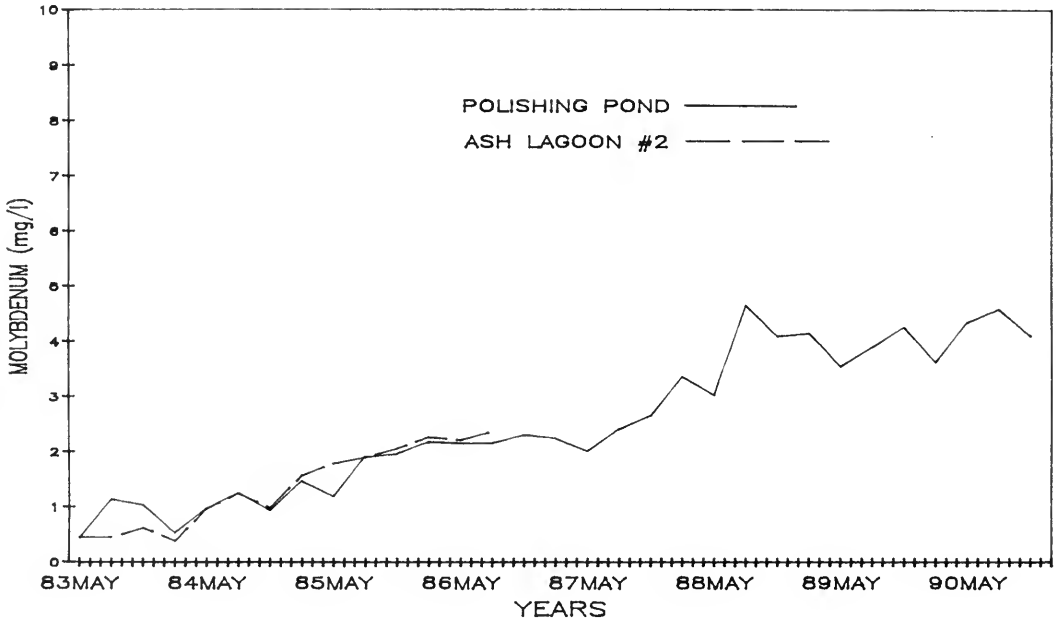


Figure 62.--Water-quality data from the Polishing Pond and Ash Lagoon No. 2 for selected constituents, 1983-1990.

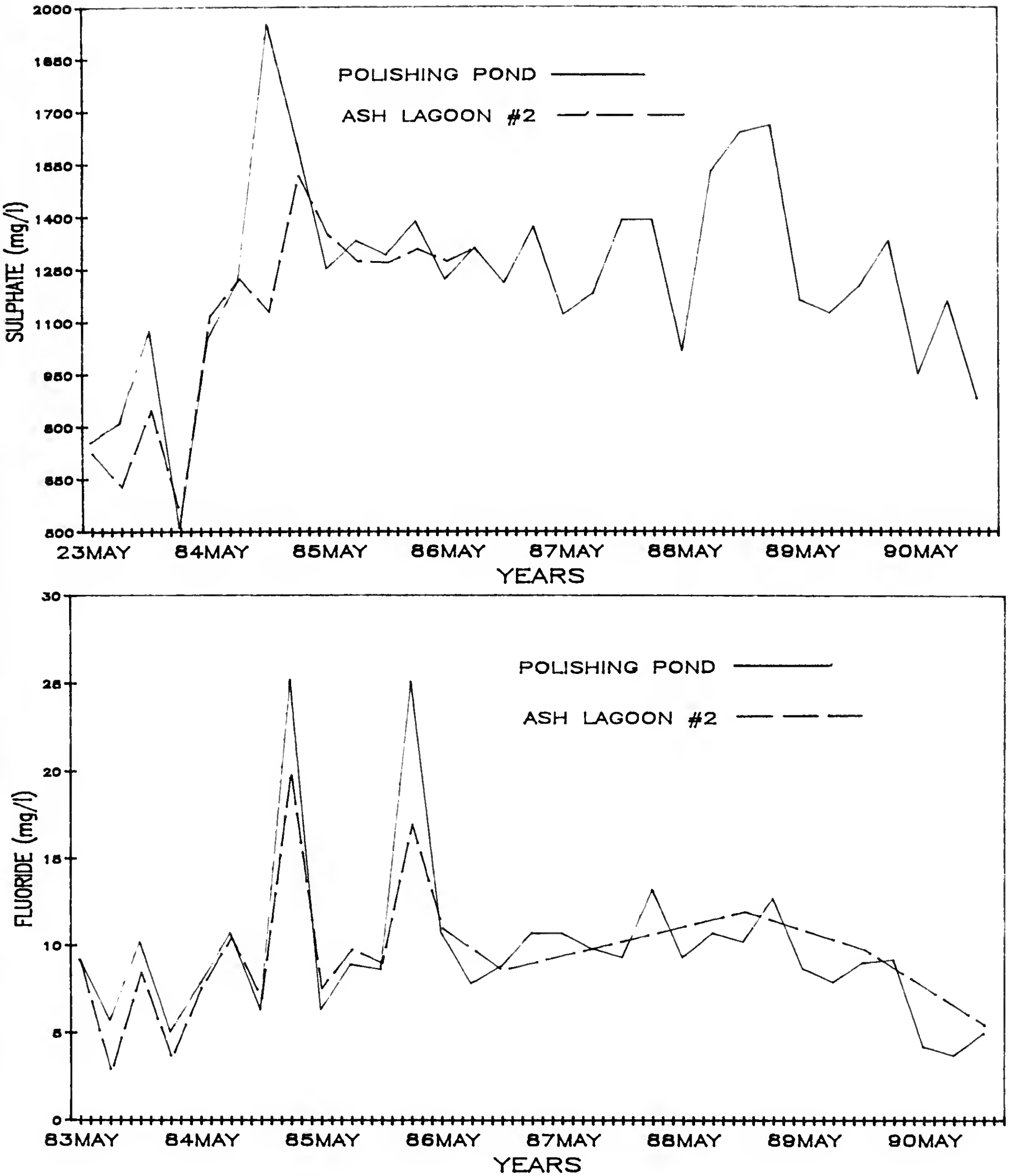


Figure 62.--Water-quality data from the Polishing Pond and Ash Lagoon No. 2 for selected constituents, 1983-1990--Continued

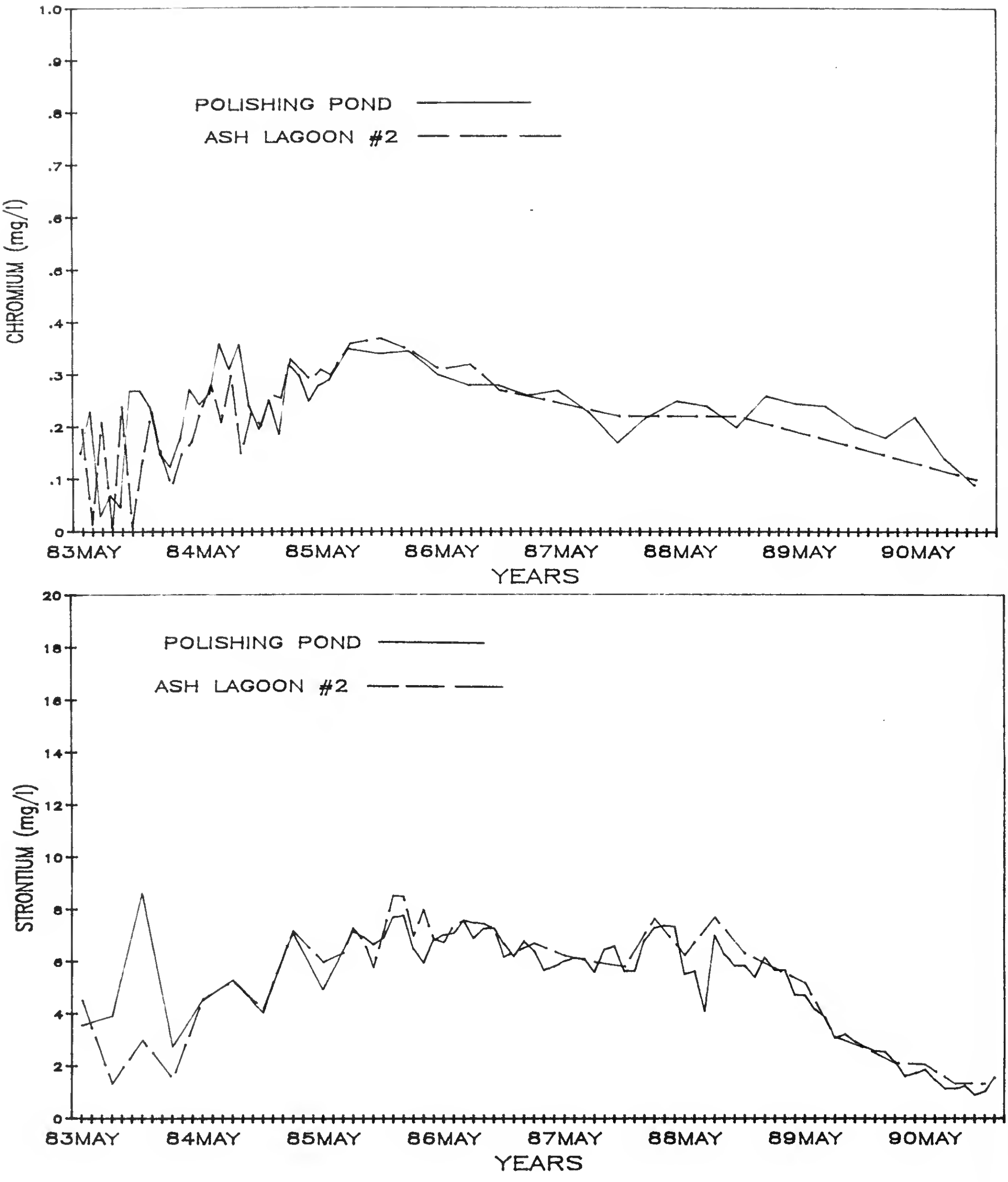
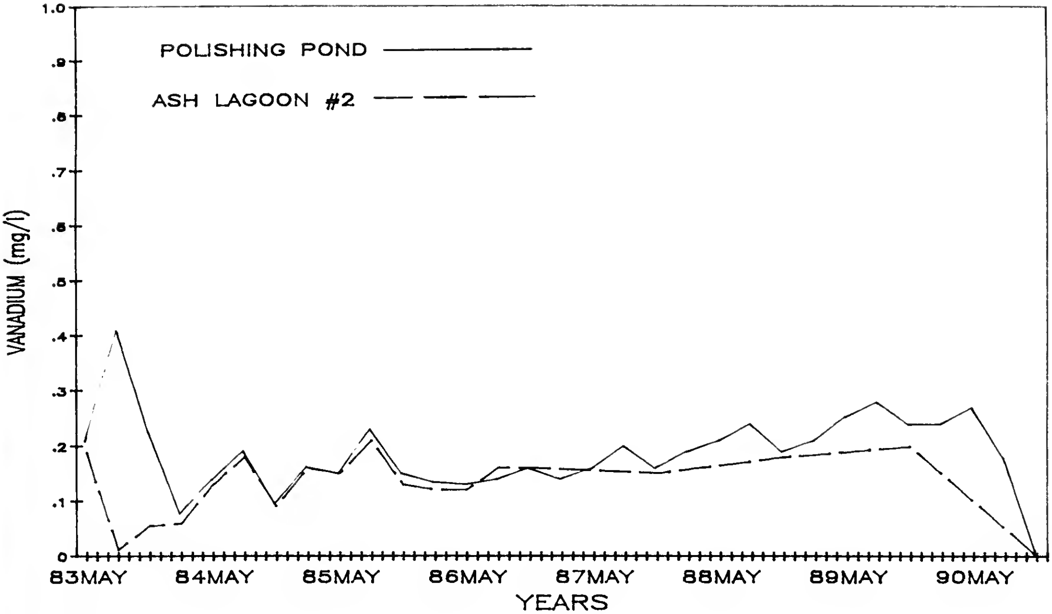


Figure 62.--Water-quality data from the Polishing Pond and Ash Lagoon No. 2 for selected constituents, 1983-1990--Continued



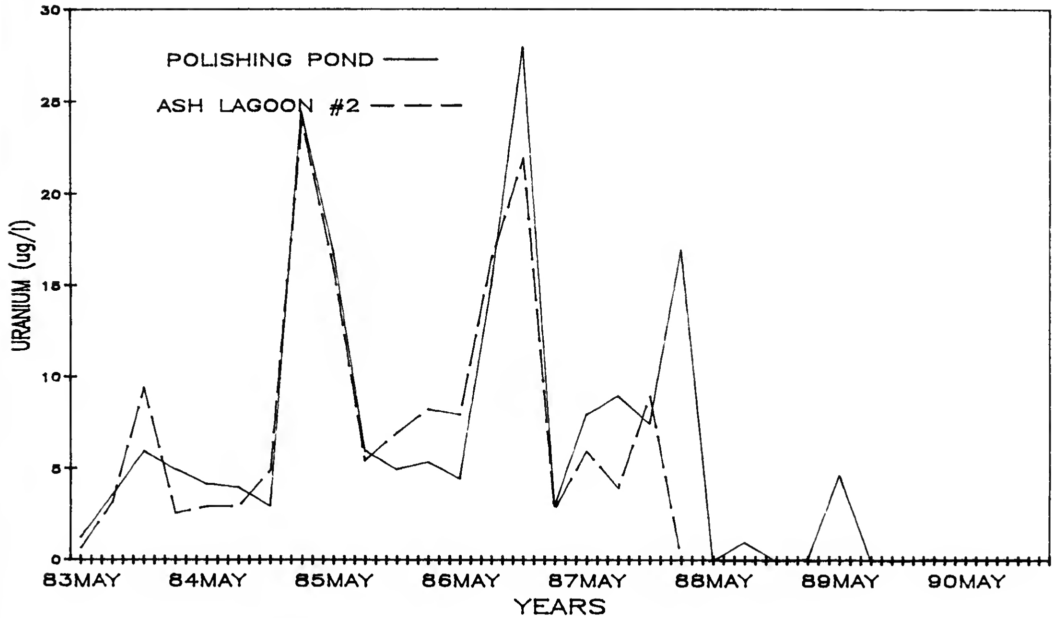
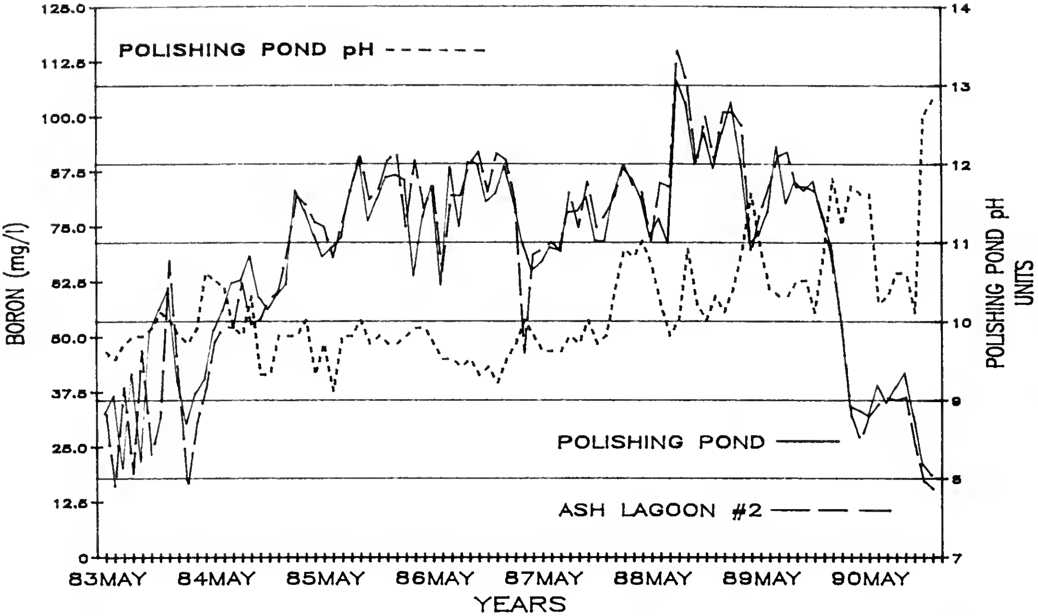


Figure 62.--Water-quality data from the Polishing Pond and Ash Lagoon No. 2 for selected constituents, 1983-1990--Continued



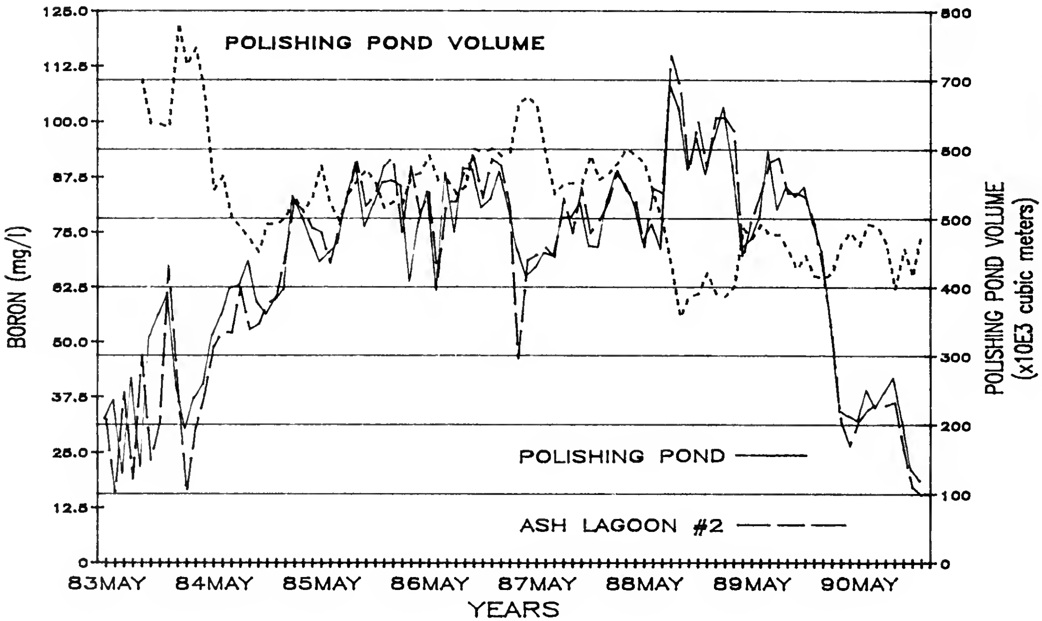
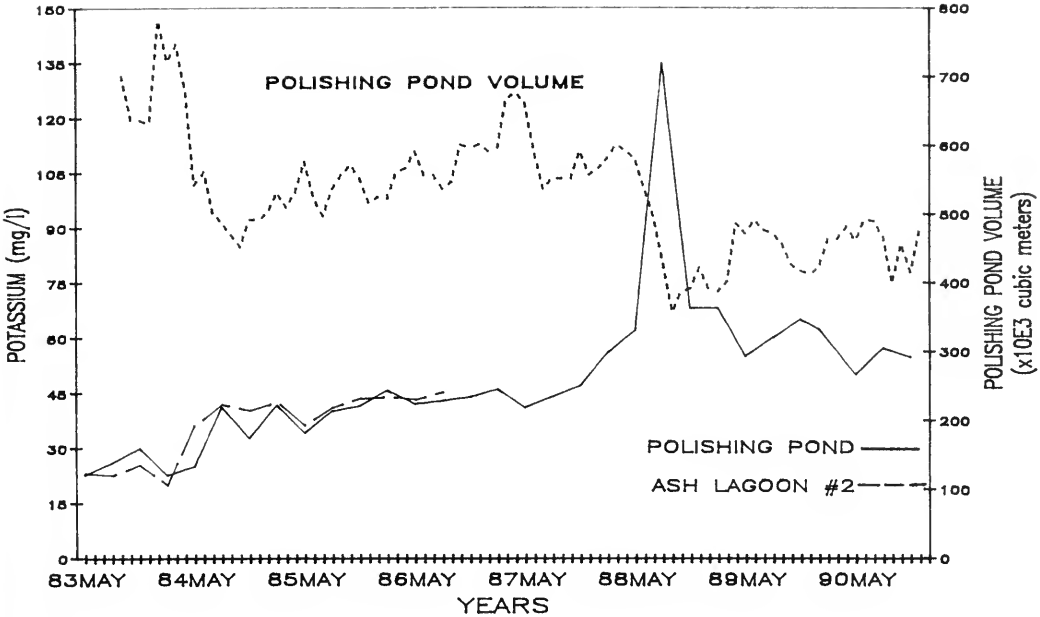


Figure 62.--Water-quality data from the Polishing Pond and Ash Lagoon No. 2 for selected constituents, 1983-1990--Continued



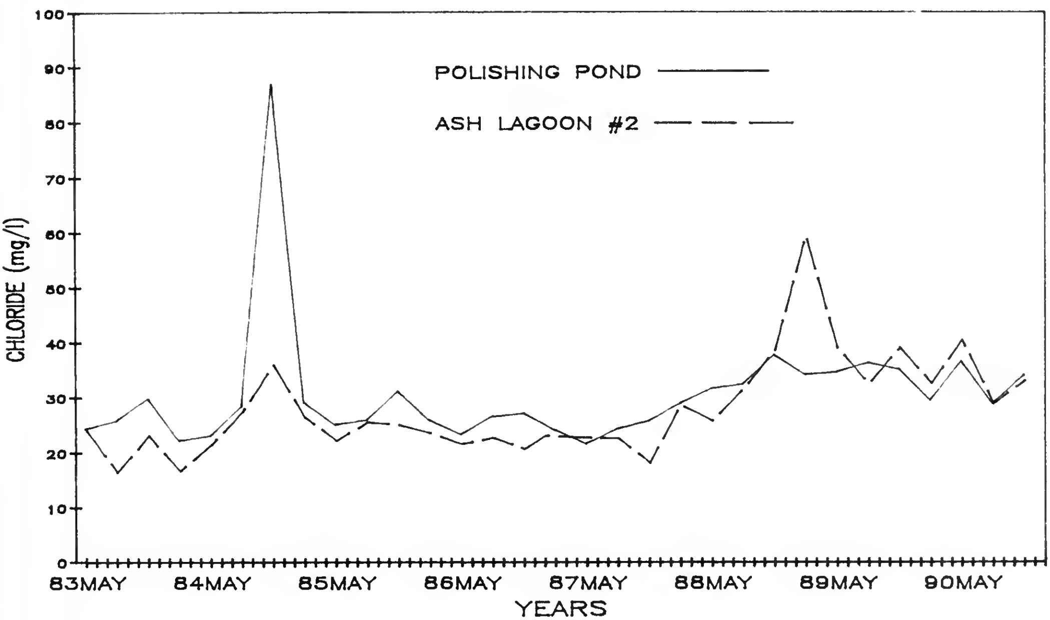


Figure 62.--Water-quality data from the Polishing Pond and Ash Lagoon No. 2 for selected constituents, 1983-1990--Continued

AIR QUALITY

Saskatchewan

Saskatchewan Environment and Public Safety

Ambient air monitoring to determine sulphur dioxide (SO_2) levels in the vicinity of the Poplar River Power Plant began in 1979. The monitoring station is located on the southern outskirts of the town of Coronach, approximately 4.0 kilometres directly north of the power plant which in turn is 5.0 kilometres north of the Canada/USA border. Saskatchewan Environment and Public Safety's hourly and 24-hour average standards for sulphur dioxide are 0.17 parts per million (ppm) and 0.06 ppm, respectively. There have been no recorded violations of the 24-hour average over the past 10 years. The hourly standard has been violated twice during the same period. Both violations occurred on June 22, 1984, at 1100 and 1200 hours with consecutive readings of 0.20 ppm. Weather information obtained at the station indicated winds blowing from the southeast quadrant at the time. As the power plant is located south of the monitoring locations, it was the most probable source. Down time for the monitor during the past 11 years has ranged from a low of 1.8% to a high of 54% , for an average of 15.9%. Figures 63 and 64 show in graphical form, maximum hourly and daily (24-hour) average readings, for the past 10 years.

Suspended particulate concentrations obtained from the high volume monitor at the same location during the past 10 years indicate at total of 26 violations of the provincial standard of 120 micrograms per cubic meter (mg/m^3/24 hrs). The highest yearly number of violations occurred in 1981, with a total of 8. The largest single concentration of 1,276 micrograms (µg) occurred in 1981, on April 16, during a severe dust

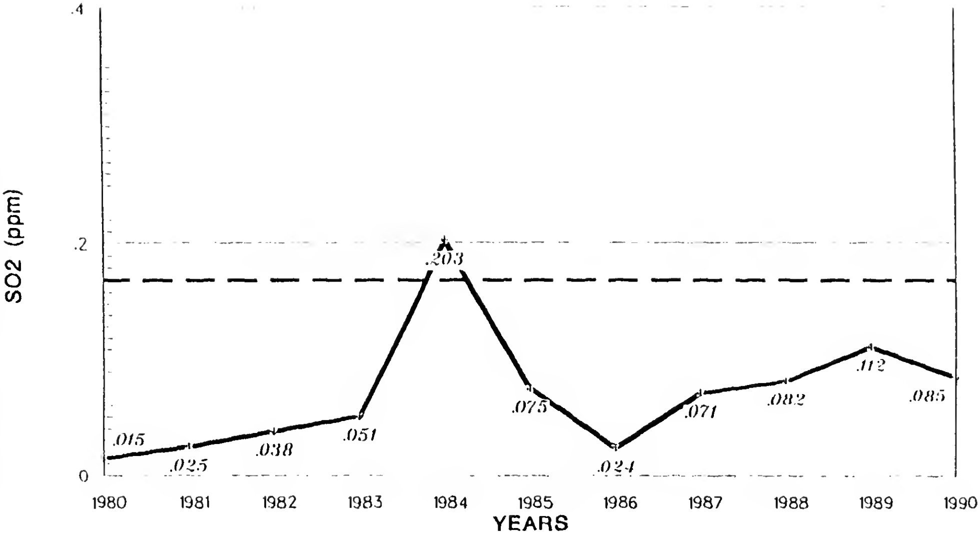


Figure 63.--Saskatchewan maximum hourly sulphur dioxide air quality data during 1989-90, Coronach water treatment plant.

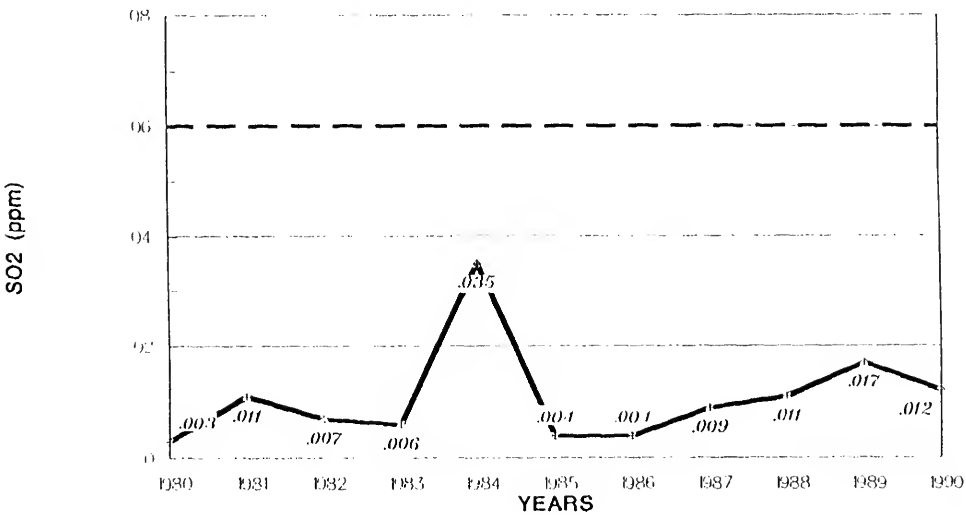


Figure 64.--Saskatchewan maximum daily sulphur dioxide air quality data during 1980-1990, Coronach water treatment plant.

storm. The remaining 25 violations cannot be attributed to the operations of the power plant and were likely caused by wind blown field dusts. The provincial geometric mean of 70 $\mu g/m^3$ has not to date been exceeded, with the highest mean of 48 µg's occurring in 1981. Annual down time for the monitor during the same period has ranged from a low of 10% to a high of 26%, for an 18% average.

During 1990, ambient sulphur dioxide monitoring recorded no violations of Saskatchewan Environment and Public Safety's hourly and 24-hour average standards of 0.17 and 0.06 ppm, respectively. The highest recorded hourly value of 0.085 ppm SO_2 was recorded on July 16 at 1200 hours, as compared to 0.112 ppm SO_2 recorded in August of 1989. Weather information obtained from the site indicated that winds at the time were blowing from the southeast. As the power plant is located south of the monitoring locations, it is the most probable source. The highest 24-hour average reading of 0.010 ppm occurred on August 23, as compared to 1989's highest 4-hour average reading of 0.017 ppm. Downtime for the monitor during the 12-month period was 1.8%, compared to 1989's 2.2%. Figures 65 and 66 show in graphical form, maximum hourly and daily (24-hour) average readings obtained at the monitoring station during the last five years.

Suspended particulate concentrations obtained from the high volume monitor at the same site for the 12-month period exceeded Saskatchewan Environment and Public Safety's 24-hour average standard of 120 $\mu g/m^3$/24 hrs on two occasions, October 2 and 26. Wind data for both dates discount the plant as the source. The annual geometric mean of 35.4 $\mu g/m^3$ is well below the provincial standard of 70.0 and is higher than 1989's 20.8. Downtime for the monitor was 23% compared to 13% in 1989.

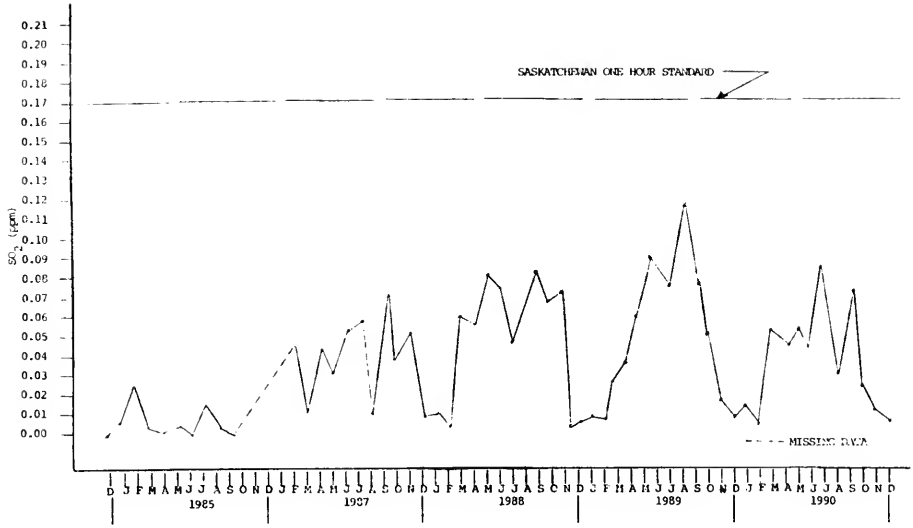


Figure 65.--Saskatchewan maximum hourly sulphur dioxide air quality data during 1985-90, Coronach water treatment plant.

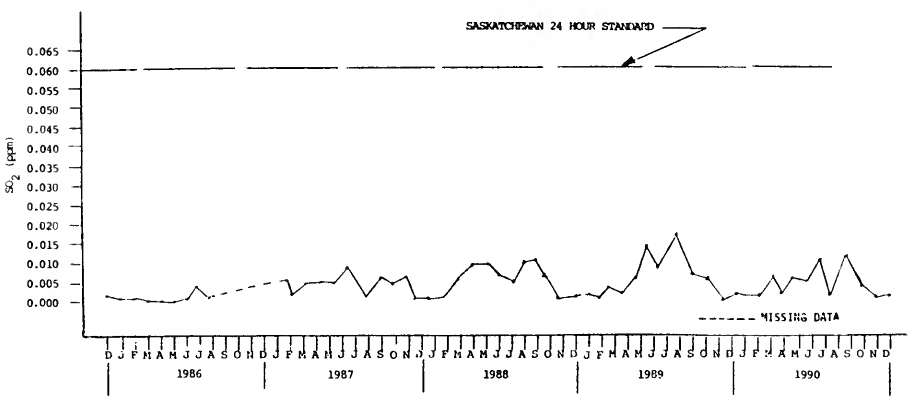


Figure 66.--Saskatchewan maximum daily sulphur dioxide air quality data during 1986-90, Coronach water treatment plant.

Sask Power

Sask Power began ambient air monitoring in 1981 near the East Poplar River near the International Boundary to determine sulphur dioxide and suspended particulate concentrations. There have been no recorded violations of the provincial 24-hour ambient SO_2 standard of 0.06 ppm, over the last 10 years. The highest maximum hourly reading during this period of 0.138 ppm occurred on January 7, 1989 at 0300 hours. Weather data gathered for that day indicated northerly winds for that period of time. As the air monitoring station is located south of the plant, the plant is the most probable source. Down time for the monitor during the past ten years has ranged from a low of less than 1% to a high of 31% , for an average of 7%.

Suspended particulate concentrations, including the average of 4 samplers in use from 1981 to 1984 and 1 sampler from 1985 to present, indicate a total of 87 violations of the provincial standard. The highest yearly number of violations during the 10 year period totaled 34, in 1984. The largest single concentration of 3,240 µg also occurred during a severe dust storm on May 10, 1989. The remaining violations could not be attributed to the power plant operations. The 10 year average geometric mean of 43.0 is well below the provincial standard of 70.0 $\mu g/m^3$, with the highest mean of 43.0 occurring in 1989. Annual down time for the samplers over the 10 year period ranged from a low of 2% to a high of 36%, for a 9% average.

During 1990, ambient SO_2 monitoring conducted at the Sask Power station located near the International Boundary showed no violations, the same as 1989. The highest hourly reading of 0.049 ppm occurred on September 30,

1989 at 1200 hours. Weather data recorded by Environment Canada's weather station located at Rockglen (37 kilometres northwest of the plant), indicated winds blowing from the plant towards the monitor at the time. This reading compares to the highest hourly reading recorded in 1989 of 0.138 ppm. Down time for the monitor was 1.3% , as compared to 1989's 3.2% .

Suspended particulate concentrations at the monitoring station exceeded Saskatchewan Environment and Public Safety's 24-hour standard on 5 occasions in 1990, the same as 1989. The highest recorded value of 1,409 $\mu g/m^3$/24 hrs occurred on October 26. This, as well as the other violations were probably caused by field blown dusts, as no specific episodes of heavy particulate release from the plant stack on violation days could be determined. The annual geometric mean of 35.4 $\mu g/m^3$ is well below the provincial standard of 70.0 and compares with the 1989 mean of 42.8. Down time for the sampler was 1.7% compared to 1989's 4.5%.

In-Stack Monitoring

Sulphur dioxide averages in 1990 were higher than those in 1989. Daily concentrations ranged from a low of 1,782 to a high of 3,769 mg/m^3 (corrected to 3% O_2 with an average yearly concentration of 2,895 as compared to 2,663 in 1989. Down time for the SO_2 in-stack monitor of 16% was the same as 1989's. Nitrogen oxide averages in 1990 were virtually the same as those in 1989 with daily concentrations ranging from a low of 336 to a high of 1,225 mg/m^3 (corrected to 3% O_2) with an average yearly concentration of 741 as compared to 774 in 1989. Down time for the NO_x in-stack monitor was the same as 1989's 16%.

Daily opacity readings ranged from 0 to 100%, with a yearly average of 37% compared to 21% in 1989. Saskatchewan's opacity standard of 40% was exceeded 2,265 times in 1990, significantly more than 1989's 768 exceedances. Down time for the opacity monitor was 4% as compared to 1989's 6%. Stack gas flow rates ranged from a low of 354 to a high of 687 m^3/second, with an average flow of 590 in 1990 which is close to 1989's 606. Down time for the 12-month period in 1990 was 1%, down considerabley from 29% in 1989.

Units No. 1 and No. 2 operated with yearly average capacity factors of 88.1% and 88.4% respectively, compared to 93.8% and 93.1% in 1989. Totals combining both units were as follows:

Coal - 3,821,978 Mg in 1990, compared to 4,172,493 in 1989.

Oil - 2,102 m^3 in 1990, compared to 1,754 in 1989.

Gross Megawatt Hours - 4,574,700 in 1990 compared to 4,851,700 in 1989.

Stack Sampling

A stack sampling survey, as per Condition 17 of Sask Power's Permit to Operate #197R6 was conducted on August 23, 1990. The results of the sampling for SO_2, NO_x, and particulates were as follows:

SO_2 - 3,057 µg/m^3 (@ 3% O_2) in 1990, compared to 2,680 mg/m^3 in 1989.

NO_x - 744 mg/m^3 (@ 3% O_2) in 1990, compared to 712 mg/m^3 in 1989.

Particulates - 474 kg/hr in 1990, compared to 351 kg/hr in 1989.

The results, as compared to Sask Power's continuous in-stack results for corresponding time periods are as shown below.

	Stack Survey	In-Stack Monitors	% Agreement
SO_2	3,057	2,971	within 3%
NO_x	744	671	within 9%

Startup and Trip Conditions

There were a number of startup and trip conditions throughout 1990. Various turbine trips occurred caused by primary air heater leaks, turbine repairs, boiler leaks, scheduled or non-scheduled maintenance overhauls or operational problems. Oil firing during startup conditions of various lengths always results in opacity level increases for periods up to 24 hours following startup.

Using the above 1990 stack emission figures and based on operations of 24-hrs/day, 292 days/yr (80% average capacity figures for Units 1 and 2) emission totals would be as follows:

Particulates - 3,322 tonnes/yr vs 2,856 tonnes in 1989

Sulphur Dioxide - 48,776 tonnes/yr vs 45,610 tonnes in 1989

Nitrogen Oxides - 11,963 tonnes/yr vs 12,643 tonnes in 1989

Montana

During 1990, the Montana Department of Health and Environmental Sciences, Air Quality Bureau (AQB) operated five sulfation plate sampling sites in the Scobey, Montana area. These were: (1) Richardson Residence; (2) Flaxville; (3) TV Tower Hill; (4) Scobey Downtown; and (5) Four Buttes. The sites were chosen to monitor potential sulfation level increases in the area due to the Sask Power generating plant near Coronach, Saskatchewan. Table 10 summarizes 1990 sulfation plate data.

Table 10.--*Sulfation rates for five Montana sites operated during 1990. Values of sulfation rate are in mg/100 cm^2/day*

Site	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Richardson	0.00	0.00	0.02	0.04	0.00	0.00	0.02	0.00	*N.D.	N.D.	N.D.	0.02
Flaxville	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02
TV Tower	0.00	0.04	0.10	0.00	0.00	0.00	0.03	0.00	0.00	0.03	0.01	0.01
Scobey	0.00	0.00	0.03	0.00	N.D.	N.D.	0.00	N.D.	0.00	0.00	N.D.	0.00
Four Buttes	0.00	0.00	0.04	0.02	0.00	N.D.	0.01	N.D.	0.00	0.00	N.D.	0.00

*Indicates no data available.

There are no federal or state standards for sulfation rate, but readings greater than 0.5 mg/100 cm^2/day indicate potential sulfation problems. Since the highest reading experienced during 1990 was only 0.1 mg/100 cm^2/day during March (TV Tower site), sulfation rates during the entire year were obviously well below the potential problem rate. In light of the low sulfation rates experienced over the decade-long sampling period, it was decided by the AQB to terminate the sulfation plate sampling network after December, 1990.

In addition to sulfation plate monitoring stations in the later 1980's, the Air Quality Bureau operated from one to three continuous air-quality monitoring stations from 1981-87. Parameters monitored included sulfur dioxide, Beta scattering coefficient, total suspended particulate, sulfates, nitrates, wind direction, and wind speed. The continuous monitoring stations were gradually phased out after determining that United States and Montana air quality standards were not being violated.

REFERENCES CITED

Integrated Environments Limited, 1991, The use of the TYDAC SPANS GIS in the assessment and review of pesticide residues detected in surface waters of the Prairie Provinces and the Northwest Territories: (prepared for Environment Canada, Inland Waters Directorate, Western and Northern Region, Water Quality Branch, Regina, Saskatchewan, 133 p.).

Irvine, J.A., Whitaker, S.H., and Broughton, P.L., 1978, Coal resources of southern Saskatchewan - A model for evaluation methodology: Note: this report is listed three ways) Geological Survey of Canada Economic Geology Report 30, Department of Mineral Resources Report 209, or Saskatchewan Research Council Report 20; Part I, P. 151, Part II, 56 oversize plates.

Munro, D., 1985, Report on Mercury in the Cookson Reservoir. Environment Canada, Western and Northern Region, WQB-WNR-85-02. 25 p.

Vanderkamp, G., and Maathuis, H., 1989, Evaluation of proposal for groundwater dewatering project below Cookson Reservoir, Saskatchewan Research Council.

Waite, D.T., Dunn, G.W., and Stedwill, R.J., 1980, Mercury in the Cookson Reservoir. Saskatchewan Department of the Environment, Water Pollution Control Section, Report #WPC 23.

Water Quality Branch, 1980. Cookson Reservoir Aquatic Quality Baseline Survey, 1979. Environment Canada, Inland Waters Directorate, Regina. Prepared for Saskatchewan Power Corporation, Contract E-021.

ANNEX 1

POPLAR RIVER

COOPERATIVE MONITORING ARRANGEMENT

CANADA-UNITED STATES

September 23, 1980

POPLAR RIVER COOPERATIVE MONITORING ARRANGEMENT

I. PURPOSE

This Arrangement will provide for the exchange of data collected as described in the attached Technical Monitoring Schedules in water quality, water quantity and air quality monitoring programs being conducted in Canada and the United States at or near the International Boundary in response to the Saskatchewan Power Corporation development. This Arrangement will also provide for the dissemination of the data in each country and will assure its comparability and assist in its technical interpretation.

The Arrangement will replace and expand upon the quarterly information exchange program instituted between Canada and the United States in 1976.

II. PARTICIPATING GOVERNMENTS

Governments and government agencies participating in the Arrangement are:

Government of Canada: Environment Canada
Government of the Province of Saskatchewan:
Saskatchewan Environment and Public Safety
Government of the United States of America: U.S. Geological Survey
Government of the State of Montana: Executive Office

III. POPLAR RIVER MONITORING COMMITTEE: TERMS OF REFERENCE

A binational committee called the Poplar River Bilateral Monitoring Committee will be established to carry out responsibilities assigned to it under this Arrangement. The Committee will operate in accordance with the following terms of reference:

A. Membership

The Committee will be composed of four representatives, one from each of the participating Governments. It will be jointly chaired By the Government of Canada and the Government of the United States. There will be a Canadian Section and a United States Section. The participating Governments will notify each other of any changes in membership on the Committee. Cochairpersons may by mutual agreement invite agency technical experts to participate in the work of the Committee.

The Governor of the State of Montana may also appoint a chief elective official of local government to participate as an ex-officio member of the Committee in its technical deliberations. The Saskatchewan Minister of the Environment may also appoint a similar local representative.

B. Functions of the Committee

The role of the Committee will be to fulfill the purpose of the Arrangement by ensuring the exchange of monitored data in accordance with the attached Technical Monitoring Schedules, and its collation and technical interpretation in reports to Governments on implementation of the Arrangement. In addition, the Committee will review the existing monitoring systems to ensure their adequacy and may recommend to the Canadian and United States Governments any modifications to improve the Technical Monitoring Schedules.

1. Information Exchange

Each Cochairperson will be responsible for transmitting to his counterpart Cochairman on a regular, and not less than quarterly basis, the data provided by the cooperative monitoring agencies in accordance with the Technical Monitoring Schedules.

2. Reports

(a) The Committee will prepare a joint Annual Report to the participating governments, and may at any time prepare joint Special Reports.

(b) Annual Reports will

i) summarize the main activities of the Committee in the year under Report and the data which has been exchanged under the Arrangement;

ii) draw to the attention of the participating governments any definitive changes in the monitored parameters, based on collation and technical interpretation of exchanged data (i.e. the utilization of summary, statistical and other appropriate techniques);

iii) draw to the attention of the participating governments any recommendations regarding the adequacy or redundancy of any scheduled monitoring operations and any proposals regarding modifications to the Technical Monitoring Schedules, based on a continuing review of the monitoring programs inluding analytical methods to ensure their comparability.

c) Special Reports may, at any time, draw to the attention of participating governments definitive changes in monitored parameters which may require immediate attention.

d) Preparation of Reports

Reports will be prepared following consultation with all committee members and will be signed by all Committee members. Reports will be separately forwarded by the Committee Cochairmen to the participating governments. All annual and special reports will be so distributed.

3. Activities of Canadian and United States Sections

The Canadian and United States section will be separately responsible for:

(a) dissemination of information within their respective countries, and the arrangement of any discussion required with local elected officials;

(b) verification that monitoring operations are being carried out in accordance with the Technical Monitoring Schedules by cooperating monitoring agencies;

(c) receipt and collation of monitored data generated by the cooperating monitoring agencies in their respective countries as specified in the Technical Monitoring Schedules;

(d) if necessary, drawing to the attention of the appropriate government in their respective countries any failure to comply with a scheduled monitoring function on the part of any cooperating agency under the jurisdiction of that government, and requesting that appropriate corrective action be taken.

IV. PROVISION OF DATA

In order to ensure that the Committee is able to carry out the terms of this Arrangement, the participating governments will use their best efforts to have cooperating monitoring agencies, in their respective jurisdictions provide on an ongoing basis all scheduled monitored data for which they are responsible.

V. TERMS OF THE ARRANGEMENT

The Arrangement will be effective for an initial term of five years and may be amended by agreement of the participating governments. It will be subject to review at the end of the initial term and will be renewed thereafter for as long as it is required by the participating governments.

ANNEX 2

POPLAR RIVER

COOPERATIVE MONITORING ARRANGEMENT

TECHNICAL MONITORING SCHEDULES

1991

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PREAMBLE

The Technical Monitoring Schedule lists those water quantity, water quality and air quality monitoring locations and parameters which form the basis for information exchange and reporting to Governments. The structure of the Committee responsible for ensuring the exchange takes place is described in the Poplar River Cooperative Monitoring Arrangement.

The monitoring locations and parameters listed herein have been reviewed by the Poplar River Bilateral Monitoring committee and represent the basic technical information needed to identify any definitive changes in water quantity, water quality and air quality at the International Boundary. The Schedule was initially submitted to Governments for approval as an attachment to the 1981 report to Governments. Changes in the sampling locations and parameters may be made by Governments based on the recommendations of the committee.

Significant additional information is being collected by agencies on both sides of the International Boundary, primarily for project management or basin-wide baseline data purposes. This additional information is usually available upon request from the collecting agency and forms part of the pool of technical information which may be drawn upon by Governments for specific study purposes. Examples of additional information are water quantity, water quality, groundwater and air quality data collected at points in the Poplar River basin not of direct concern to the Committee. In addition, supplemental information on parameters such as vegetation, soils, fish and waterfowl populations and aquatic vegetation is also being collected on either a routine or specific studies basis by various agencies.

POPLAR RIVER

COOPERATIVE MONITORING ARRANGEMENT

TECHNICAL MONITORING SCHEDULES

1991

CANADA

STREAMFLOW MONITORING

Responsible Agency: Environment Canada

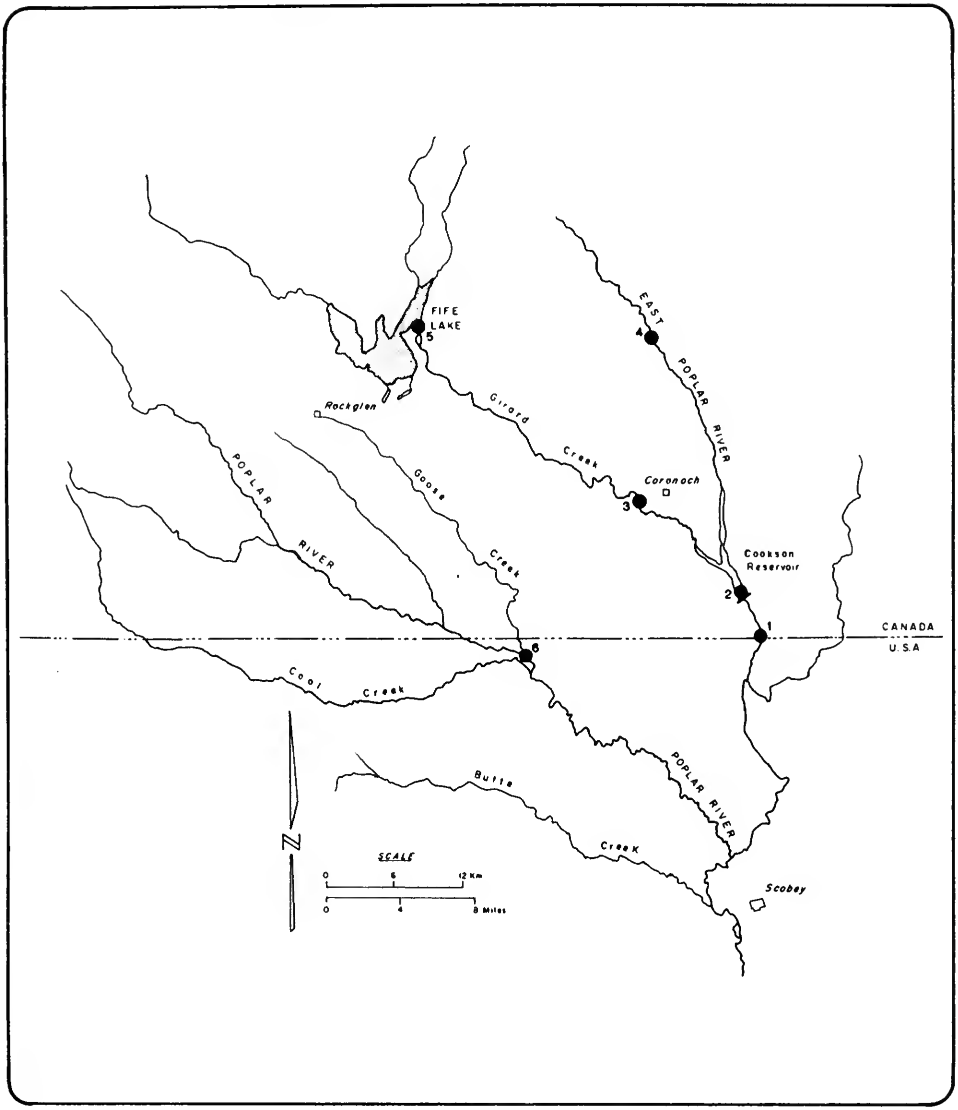
Daily mean discharge or levels and instantaneous monthly extremes as normally published in surface water data publications.

No. on Map	Station No.	Station Name
1	11AE003 (06178500)	East Poplar River at International Boundary
2	11AE013	Cookson Reservoir near Coronach
3	11AE015	Girard Creek near Coronach Cookson Reservoir
*4	11AE014	East Poplar River above Cookson Reservoir
5	**Fife Lake Overflow	
*6	11AE008 (06178000)	Poplar River at International Boundary

* International gauging station

** Miscellaneous measurements of outflow to be made by Saskatchewan Water during periods of outflow only.

HYDROMETRIC GAUGING STATIONS (CANADA)



SURFACE WATER QUALITY

Sampling Locations

Responsible Agency: Saskatchewan Environment and Public Safety

No. on Map	Station No.	Station Name
1	01SK02000002	Fife Lake Overflow
2	05SK02000007	Girard Creek at Coronach Reservoir Outflow
3	05SK02000008	Upper End of Cookson Reservoir at Highway 36
4	05SK02000004	Cookson Reservoir near Dam
5	05SK02000003	East Poplar River at culvert immediately below Cookson Reservoir

Responsible Agency: Environment Canada

6	00SA11AE0008	East Poplar River at International Boundary

PARAMETERS

Responsible Agency: Saskatchewan Environment and Public Safety

ESQUADAT* Code	Parameter	Analytical Method	Sampling Frequency Station No. 1	2	3	4	5
10151	Alkalinity-pheno	Pot. Titration	OF	Q	Q	Q	Q
10101	Alkalinity-tot	Pot. Titration	OF	Q	Q	Q	Q
13004	Aluminum tot	AA-direct		A	A	A	A
33004	Arsenic-tot	Flameless-A.A.		A	A	A	A
06201	Bicarbonates	Calculated	OF	Q	Q	Q	Q
05451	Boron-tot	ICPA	W	Q	Q	Q	Q
48002	Cadmium-tot	AA-Solvent extract (MIBK)		A	A	A	A
20103	Calcium	AA-direct	OF	Q	Q	Q	Q
06052	Carbon-tot Inorg.	IR	OF		Q	Q	Q
06005	Carbon-tot Org.	IR	OF		Q	Q	Q
06301	Carbonates	Calculated	OF	Q	Q	Q	Q
17203	Chloride	Colourimetry	OF	Q	Q	Q	Q
06711	Chlorophyll 'a'	Colourimetry		Q	Q	Q	Q
24004	Chromium-tot	AA-Direct		A	A	A	A
36012	Coliform-fec	MF	OF	Q	Q	Q	Q
36002	Coliform-tot	MF	OF	Q	Q	Q	Q
02041	Conductivity	Conductivity Meter	W	Q	Q	Q	Q
29005	Copper-tot	AA-Solvent extract (MIBK)		A	A	A	A
09105	Flouride	Specific ion electrode		A	A	A	A
82002	Lead-tot	AA-Solvent extract (MIBK)		A	A	A	A
12102	Magnesium	AA-Direct	OF	Q	Q	Q	Q
80011	Mercury-tot	Flameless AA		A	A	A	A
42005	Molybdenum	AA-Solvent extract (MIBK)		A	A	A	A
07015	N-TKN	Colourimetry	OF	Q	Q	Q	Q
10401	NFR	Gravimetric	OF	Q	Q	Q	Q
10501	NFR (F)	Gravimetric	OF	Q	Q	Q	Q
28002	Nickel-tot	AA-Solvent extract (MIBK)	OF	Q	Q	Q	Q
07110	Nitrate + NO2	Colourimetry	OF	Q	Q	Q	Q
06521	Oil and Grease	Pet. Ether Extraction		A	A	A	A
08102	Oxygen-diss	Meter	OF	Q	Q	Q	Q
15406	Phophorus-tot	Colourimetry	OF	Q	Q	Q	Q
19103	Potassium	Flame Photometery	OF	Q	Q	Q	Q
34005	Selenium-Ext	Hydride Generation		A	A	A	A
11103	Sodium	Flame Photometry	OF	Q	Q	Q	Q
16306	Sulphate	Colourimetry	OF	Q	Q	Q	Q
10451	TDS	Gravimetric	OF	Q	Q	Q	Q
02061	Temperature	Thermometer	OF	Q	Q	Q	Q
23004	Vanadium-tot	AA-Direct		A	A	A	A
30005	Zinc-tot	AA-Solvent extract (MIBK)		A	A	A	A
10301	pH	Electrometric	W	Q	Q	Q	Q

* Computer storage and retrieval system - Saskatchewan Environment and Public Safety.

Symbols: W - Weekly during overflow; OF - Once during each period of overflow greater than 2 weeks' duration; Q - Quarterly; A - Annually in the fall; AA - Atomic absorption; IR - Infrared; Pot - Potentiometric; NFR - Nonfilterable residue; ICPA - Plasma emission; MF - Membrane filtration. NFRF - Nonfilterable residue, fixed; AA - Solvent Extract (MIBK) - Sample digested with HNO3 and extracted with methyl isobutyl ketone;

PARAMETERS (Continued)

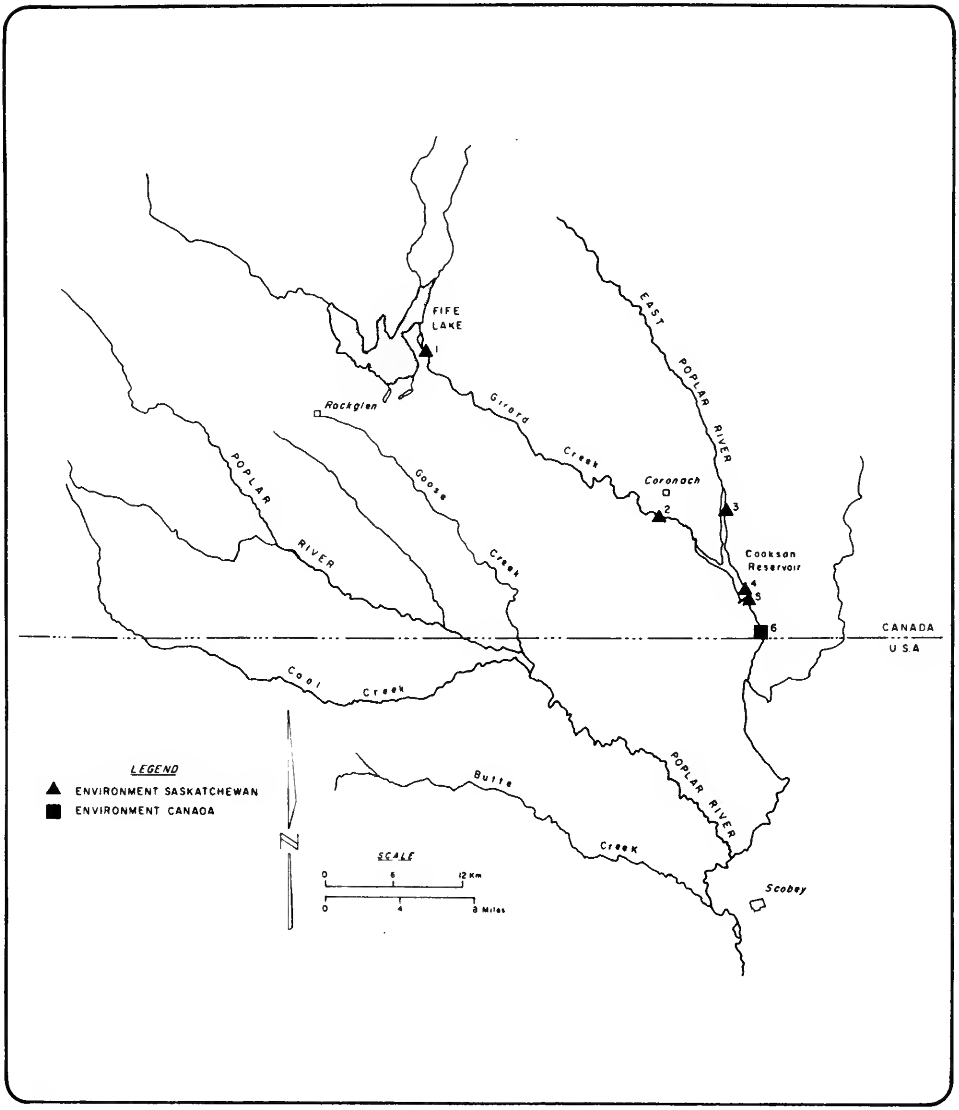
Responsible Agency: Environment Canada

NAQUADAT Code	Parameter	Analytical Method	Sampling Frequency Station No. 6
10151	Alkalinity-pheno	Potentiometric	BM
10111	Alkalinity-tot	Potentiometric	BM
13102	Aluminum-Diss.	AA-Direct	BM
13302	Aluminum-ext	AA-Direct	BM
07570	Ammonia-Free	Calculated	BM
07540	Ammonia-tot	Colourimetric	BM
33108	Arsenic-diss	Plasma	BM
56001	Barium-tot	AA-Direct	BM
06201	Bicarbonates	Calculated	BM
05009	Boron-diss	ICAP	BM
48002	Cadmium-tot	AA Solv. Ext.	BM
20103	Calcium	AA-Direct	BM
06104	Carbon-diss org	IR Detector	BM
06901	Carbon-partic	Elemental Analyzer	BM
06002	Carbon-tot Org	Calculated	BM
06301	Carbonates	Calculated	BM
17206	Chloride	Colourimetric	BM
06717	Chlorophyll a	Spectrophotometric	BM
24003	Chromium-tot	AA-Solv. Ext.	BM
27002	Cobalt-tot	AA-Solv. Ext.	BM
36012	Coliform-fec	MF	BM
36002	Coliform-tot	MF	BM
02021	Colour	Comparator	BM
02041	Conductivity	Wheatstone Bride	BM
29005	Copper-tot	AA-Solv. Ext.	BM
06610	Cyanide	UV-Colourimetric	BM
09117	Fluoride-diss	Electrometric	BM
10602	Hardness	Calculated	BM
08501	Hydroxide	Calculated	BM
26104	Iron-diss	AA-Direct	BM
82002	Lead-tot	AA-Solv. Ext.	BM
12102	Magnesium	AA-Direct	BM
25104	Manganese-diss	AA-Direct	BM
80011	Mercury-tot	Flameless AA	BM
07901	N-particulate	Elemental Analyzer	BM
07651	N-tot diss	UV Colourimetric	BM
10401	NFR	Gravimetric	BM
28002	Nickel-tot	AA-Solv. Ext.	BM
07110	Nitrate/Nitrite	Colourimetric	BM
07603	Nitrogen-tot	Calculated	BM
180XX	Organo Chlorines	GC	BM
08101	Oxygen-diss	Winkler	BM
15901	P-particulate	Calculated	BM
15465	P-tot diss	Colourimetric	BM
185XX	Phenoxy Herbicides	GC	BM
15423	Phosphorus-tot	Colourimetric (TRAACS)	BM
19103	Potassium	Flame Emission	BM
11250	Percent Sodium	Calculated	BM
00210	Sat Index	Calculated	BM
34108	Selenium-diss	Plasma	BM
14108	Silica	Colourimetric	BM
11103	Sodium	Flame Emission	BM
00211	Stab Index	Calculated	BM
16306	Sulphate	Colourimetric	BM
00201	TDS	Calculated	BM
02061	Temperature	Digital Thermometer	BM
02081	Turbidity	Nephelometric	BM
23002	Vanadium-tot	AA-Solv. Ext.	BM
30005	Zinc-tot	AA-Solv. Ext.	BM
10301	pH	Electrometric	BM
92111	Uranium	Fluometric	MC

* - Computer Storage and Retrieval System -- Environment Canada

AA - Atomic Absorption
UV - Ultraviolet
MC - Monthly Composite
MF - Membrane Filtration
NFR - Nonfilterable Residue
BM - Bimonthly (Alternate months sampled by U.S.G.S.)
IR - Infrared
GC - Gas Chromatography

SURFACE WATER QUALITY MONITORING STATIONS (CANADA)



GROUND WATER QUALITY MONITORING

SAMPLING LOCATIONS

Responsible Agency: Saskatchewan Environment and Public Safety

Map Location No.	SPC Piezometer No.	Station Description: Tip of Screen Elevation (m)	Station Description: Material
8a	C726A	746.338	unoxidized till
	C726C	752.739	oxidized till
8a	C726E	738.725	Empress gravel
9a	C728A	753.405	oxidized till
	C728B	743.265	unoxidized till
	C728C	747.645	mottled till
	C728D	752.305	oxidized till
9a	C728E	739.912	Empress gravel
2a	C712B	746.112	oxidized till
2b	C718	748.385	mottled till
2c	C719	747.715	oxidized till
22	C533	740.441	Empress gravel
23	C534	753.449	till
18	C741**	735.153	Empress gravel
21	C742**	741.800	Empress gravel
24	C714A	745.333	unoxidized till
25	C714D	750.459	oxidized till
26	C714E	738.230	Empress gravel
27	C774B	749.370	oxidized till
28	C775A	753.320	oxidized till
29	C775D	740.190	Empress gravel

PARAMETERS

Responsible Agency: Saskatchewan Environment and Public Safety

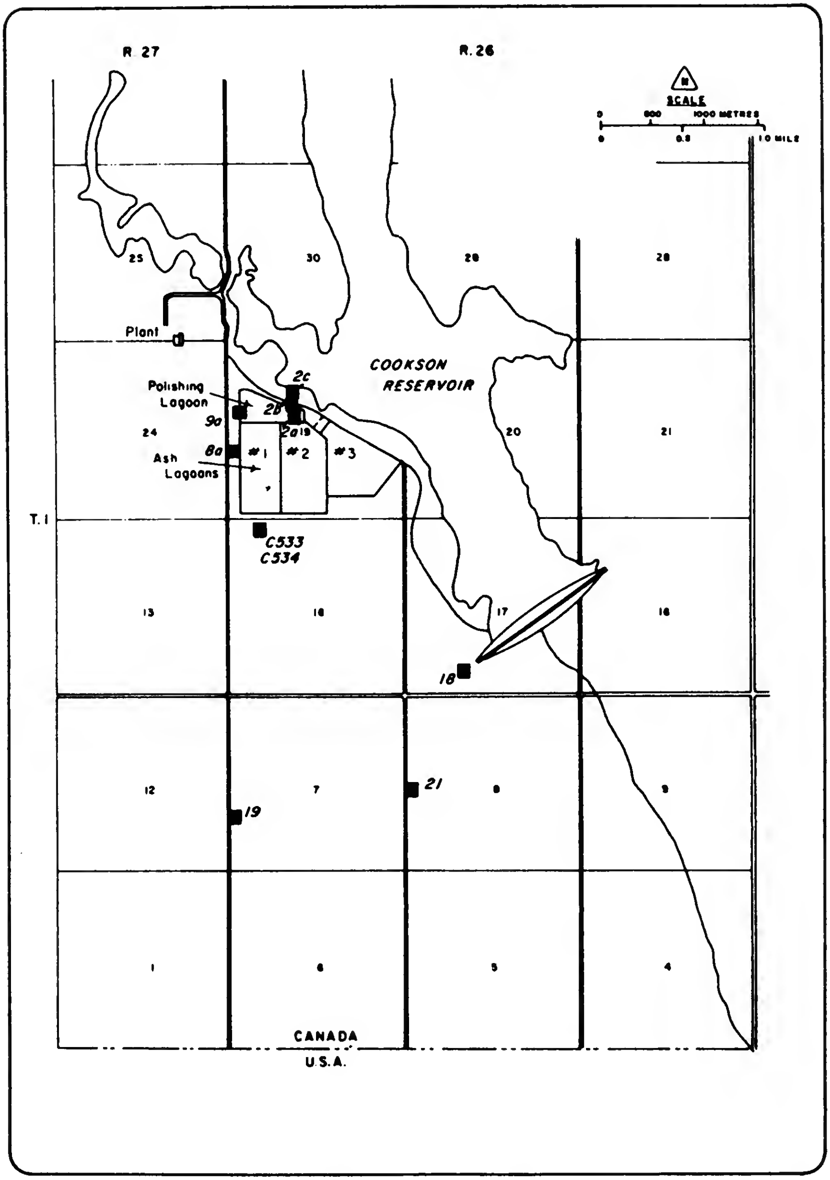
ESQUADAT* Code	Parameter	Analytical Method	Sampling Frequency Station No. Piezometers
10101	Alkalinity-tot	Pot-Titration	A
13105	Aluminum-Diss	AA-Direct	3**
33104	Arsenic-Diss	Flameless AA	A
56104	Barium-Diss	AA-Direct	A
06201	Bicarbonates	Calculated	A
05106	Boron-Diss	Colourimetry	3**
48102	Cadmium-Diss	AA-Solvent Extract (MIBK)	A
20103	Calcium-Diss	AA-Direct	A
06301	Carbonates	Calculated	A
17203	Chloride-Diss	Colourimetry	A
24104	Chromium-Diss	AA-Direct	A
27102	Cobalt-Diss	AA-Solvent Extract (MIBK)	A
02011	Colour	Comparator	A
02041	Conductivity	Conductivity Meter	3**
29105	Copper-Diss	AA-Solvent Extract (MIBK)	A
09103	Fluoride-Diss	Specific Ion Electrode	A
26104	Iron-Diss	AA-Direct	A
82103	Lead-Diss	AA-Solvent Extract (MIBK)	A
12102	Magnesium-Diss	AA-Direct	A
25104	Manganese-Diss	AA-Direct	A
80111	Mercury-Diss	Flameless AA	A
42102	Molybdenum-Diss	AA-Solvent Extract (N-Butyl acetate)	A
10301	pH	Electrometric	3**
19103	Potassium-Diss	Flame Photometry	A
34105	Selenium-Diss	Hydride generation	A
14102	Silica-Diss	Colourimetry	A
11103	Sodium-Diss	Flame Photometry	A
38101	Strontium-Diss	AA-Direct	3**
16306	Sulphate-Diss	Colourimetry	3**
10451	TDS	Gravimetric	3**
92111	Uranium-Diss	Fluorometry	3**
23104	Vanadium-Diss	AA-Direct	A
97025	Water Level		A
30105	Zinc-Diss	AA-Solvent Extract (MIBK)	A

No zinc or iron for Piezometers C533 or C534.
* Computer storage and retrieval system
-- Saskatchewan Environment and Public Safety
** Analyze annually only for Piezometers Nos. C741 and C742

SYMBOLS: AA - Atomic absorption
A - Annually. 3 -3 times/year

AA - Solvent Extract (MIBK) - sample acidified and extracted with Methyl Isobutyl Ketone.

GROUND WATER QUALITY MONITORING (CANADA)



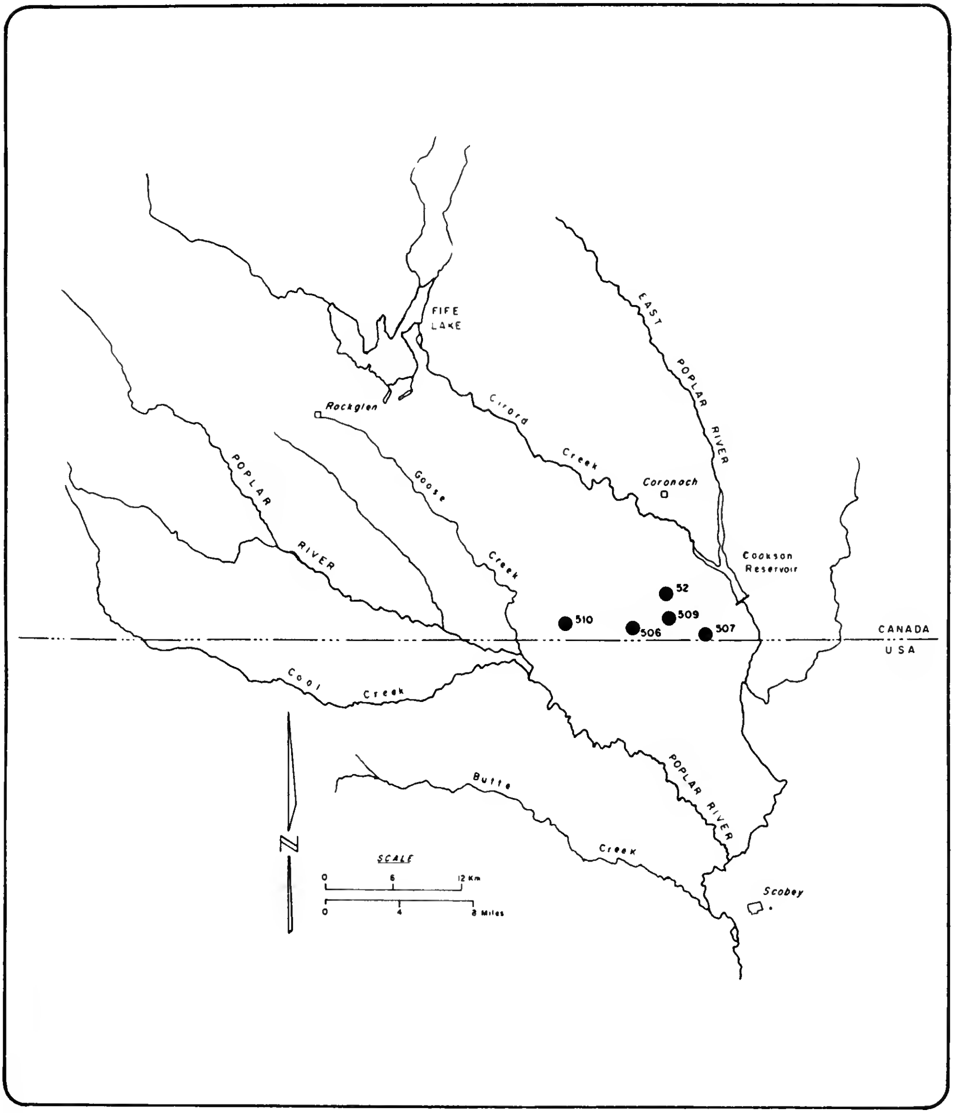
GROUND WATER PIEZOMETERS TO MONITOR POTENTIAL DRAWDOWN
DUE TO COAL SEAM DEWATERING

Responsible Agency: Saskatchewan Environment and Public Safety

Measurement Frequency: Quarterly

Piezometer Number	Location	Tip of Screen Elevation (m)	Perforation Zone (depth in metres)
52	NW 14-1-27 W3	738.43	43 - 49 (in coal)
506A	SW 4-1-27 W3	748.27	81 - 82 (in coal)
507	SW 6-1-26 W3	725.27	34 - 35 (in coal)
509	NW 11-1-27 W3	725.82	76 - 77 (in coal)
510	NW 1-1-28 W3	769.34	28 - 29 (in layered coal and clay)

GROUNDWATER PIEZOMETERS TO MONITOR POTENTIAL DRAWNDOWN DUE TO COAL SEAM DEWATERING



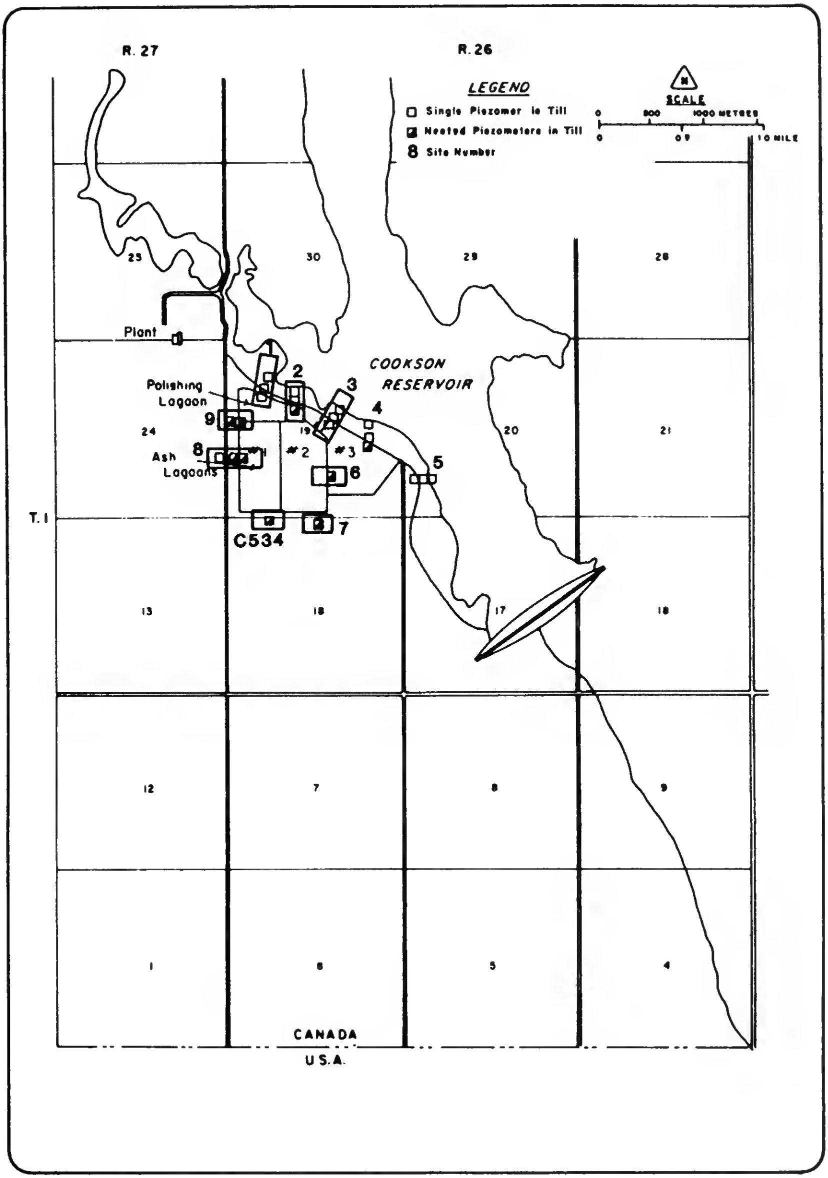
GROUNDWATER PIEZOMETER LEVEL MONITORING -- ASH LAGOON AREA

Schedule A -- Piezometers in Till

Responsible Agency: Saskatchewan Environment and Public Safety

Station	Piezometer No.	Frequency of Measurement
1a	C716	All piezometer levels are measured quarterly.
1b	C717	
1c	C711	
$2a_1$	C712A	
$2a_2$	C712B	
$2a_3$	C712C	
$2a_4$	C712D	
2b	C718	
2c	C719	
3a	C713	
3b	C720	
3c	C721	
$6a_1$	C763A	
$6a_2$	C763B	
$6a_3$	C763C	
$6a_4$	C763D	
$7a_1$	C729A	
$7a_2$	C729B	
$7a_3$	C729C	
$7a_4$	C729D	
C534	C534	
$8a_1$	C730A	
$8a_2$	C730B	
$8a_3$	C730C	
$8a_4$	C730D	
$8b_1$	C727A	
$8b_2$	C727B	
$8b_3$	C727C	
$8c_1$	C726A	
$8c_2$	C726B	
$8c_3$	C726C	
8d	C748	
$9a_1$	C764A	
$9a_2$	C764B	
$9a_3$	C764C	
$9a_4$	C764D	
$9b_1$	C728A	
$9b_2$	C728B	
$9b_3$	C728C	
$9b_4$	C728D	

PIEZOMETER INSTALLATION SITES
-- SCHEDULE "A" PEIZOMETERS IN TILL



GROUNDWATER PIEZOMETER LEVEL MONITORING
-- ASH LAGOON AREA AND INTERNATIONAL BOUNDARY AREA

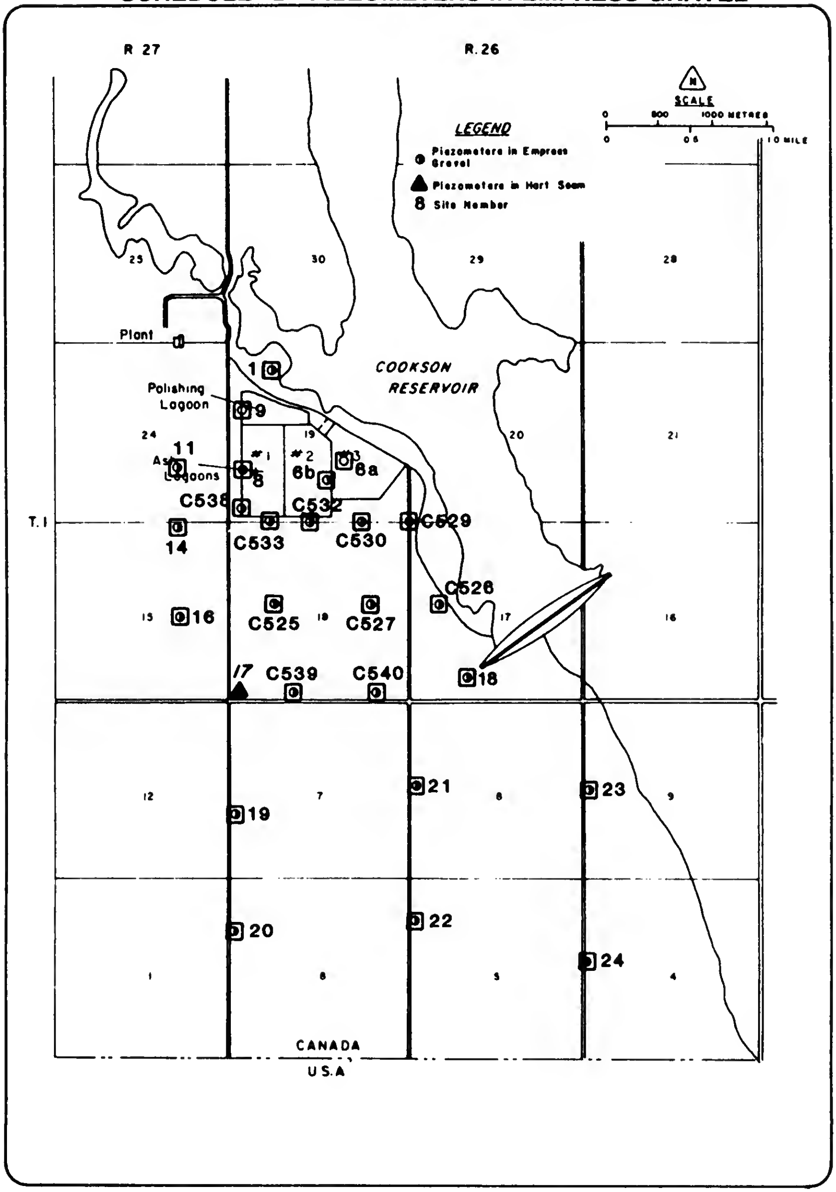
Schedule B - Piezometers in Empress Gravel

Responsible Agency: Saskatchewan Environment and Public Safety

Station	Piezometer No.	Frequency of Measurement
	IMMEDIATE ASH LAGOON AREA	
1	C731	All piezometers are monitored quarterly
6a	C763	
6b	C765A	
C529	C529	
C530	C530	
C532	C532	
C533	C533	
C538	C538	
8	C730E	
9	C728E	
	WEST OF ASH LAGOON AREA	
11	C743	
14	C740	
16	C756	
	SOUTH OF ASH LAGOON AREA	
C525	C525	
C526	C526	
C527	C527	
C539	C539	
C540	C540	
18	C741	
20*	C736	
21	C742	
22	C733	
23	C732	
24	C734	

* Inactive as of 1989

PIEZOMETER INSTALLATION SITES
– SCHEDULE "B" PIEZOMETERS IN EMPRESS GRAVEL



AMBIENT AIR QUALITY MONITORING

Responsible Agency: Saskatchewan Environment and Public Safety

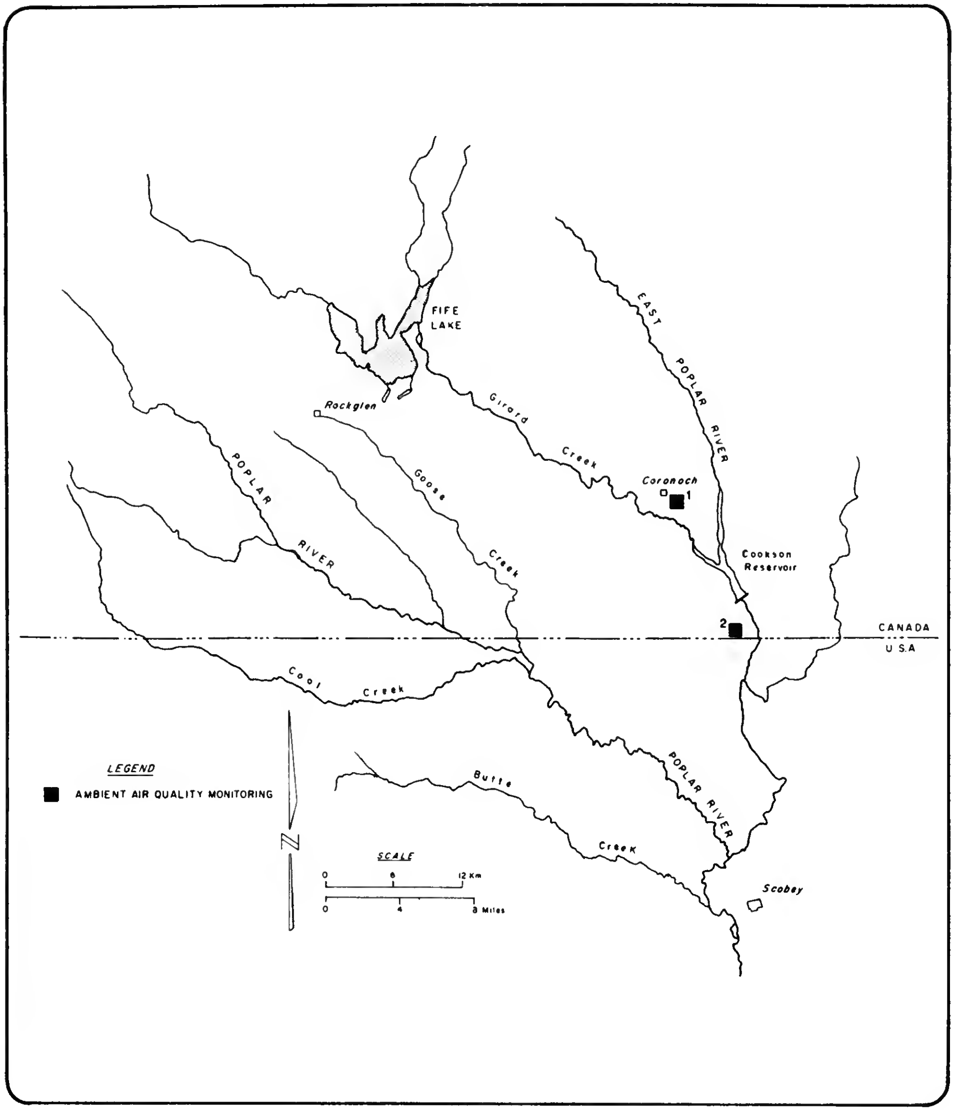
No. on map	Location	Parameters	Reporting frequency
1	Coronach	Sulphur Dioxide	Continuous monitoring with hourly averages as summary statistics.
		Wind speed and direction	Continuous monitoring with hourly averages as summary statistics.
		Total Suspended Particulates	24-hour samples on a 6-day cycle, corresponding to the National Air Pollution Surveillance Sampling Schedule.
2	International Boundary*	Sulphur Dioxide	Continuous monitoring with hourly averages as summary statistics.
		Total Suspended Particulates	24-hour samples on 6-day cycle, corresponding to the National Air Pollution Surveillance Sampling Schedule.

METHODS

Sulphur Dioxide	Saskatchewan Environment and Public Safety Colourimetric Titration, Pulsed Fluorescence
Total Suspended Particulates	Saskatchewan Environment and Public Safety High Volume Method

* This station operated by Sask Power.

AMBIENT AIR QUALITY MONITORING (CANADA)



SOURCE EMISSION MONITORING

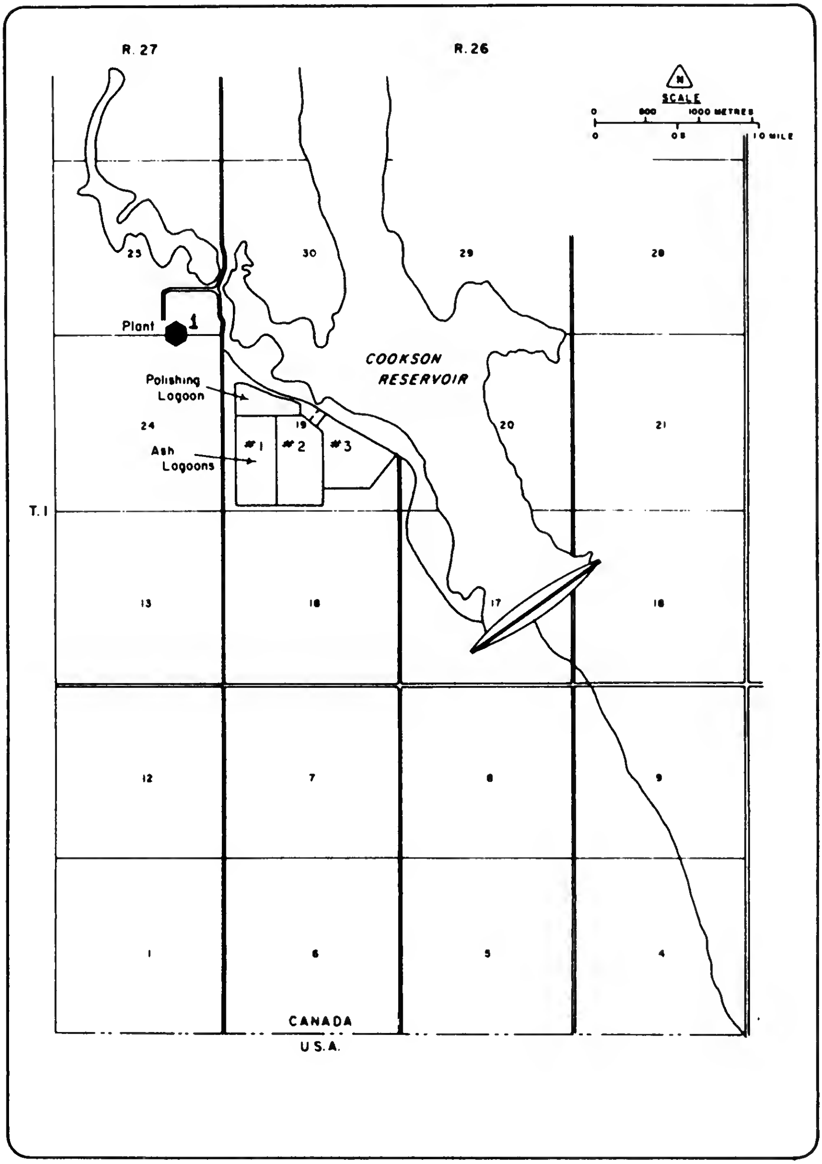
Responsible Agency: Saskatchewan Environment and Public Safety

No. on map	Station Location	Parameters	Sampling Frequency
1	At Poplar River Power Plant	Sulphur Dioxide, Nitrogen Dioxide, Opacity.	Continuously reported as Hourly Averages

METHODS

Sulphur Dioxide	Saskatchewan Environment and Public Safety - Ultraviolet Absorption
Nitrogen Dioxide	Saskatchewan Environment and Public Safety - Chemiluminescence
Opacity	Saskatchewan Environment and Public Safety - Optical

SOURCE EMISSION MONITORING



POPLAR RIVER

COOPERATIVE MONITORING ARRANGEMENT

TECHNICAL MONITORING SCHEDULES

1991

UNITED STATES

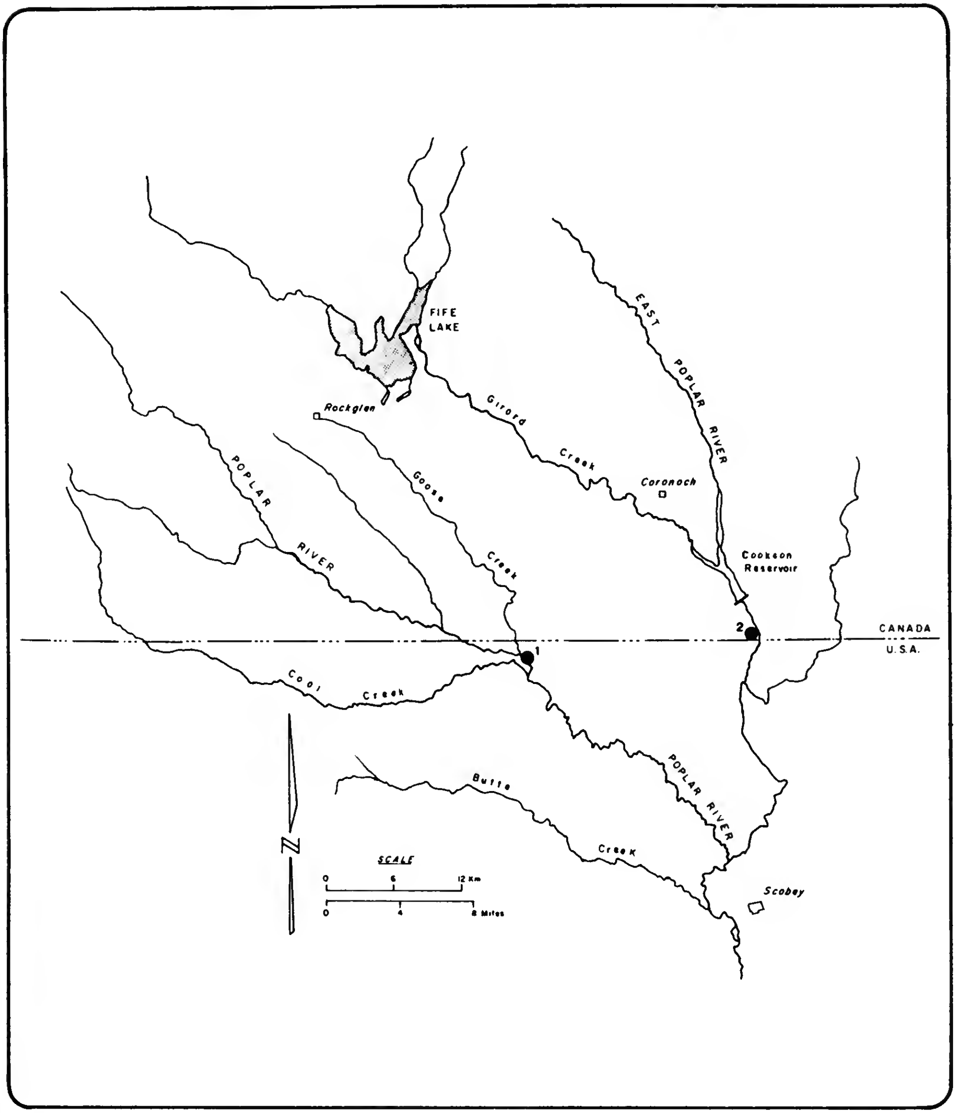
STREAMFLOW MONITORING

Responsible Agency: United States Geological Survey

No. on Map	Station Number	Station Name
1*	06178000 (11AE008)	Poplar River at International Boundary
2*	06178500 (11AE003)	East Poplar River at International Boundary

*International Gauging Station

HYDROMETRIC GAUGING STATIONS (UNITED STATES)



SURFACE WATER QUALITY MONITORING

Station Location

Responsible Agency: U.S. Geological Survey

No. on Map	USGS Station No.	Station Name
1	06178000	Poplar River at International Boundary
2	06178500	East Poplar River at International Boundary
3	06179000	East Poplar River near Scobey

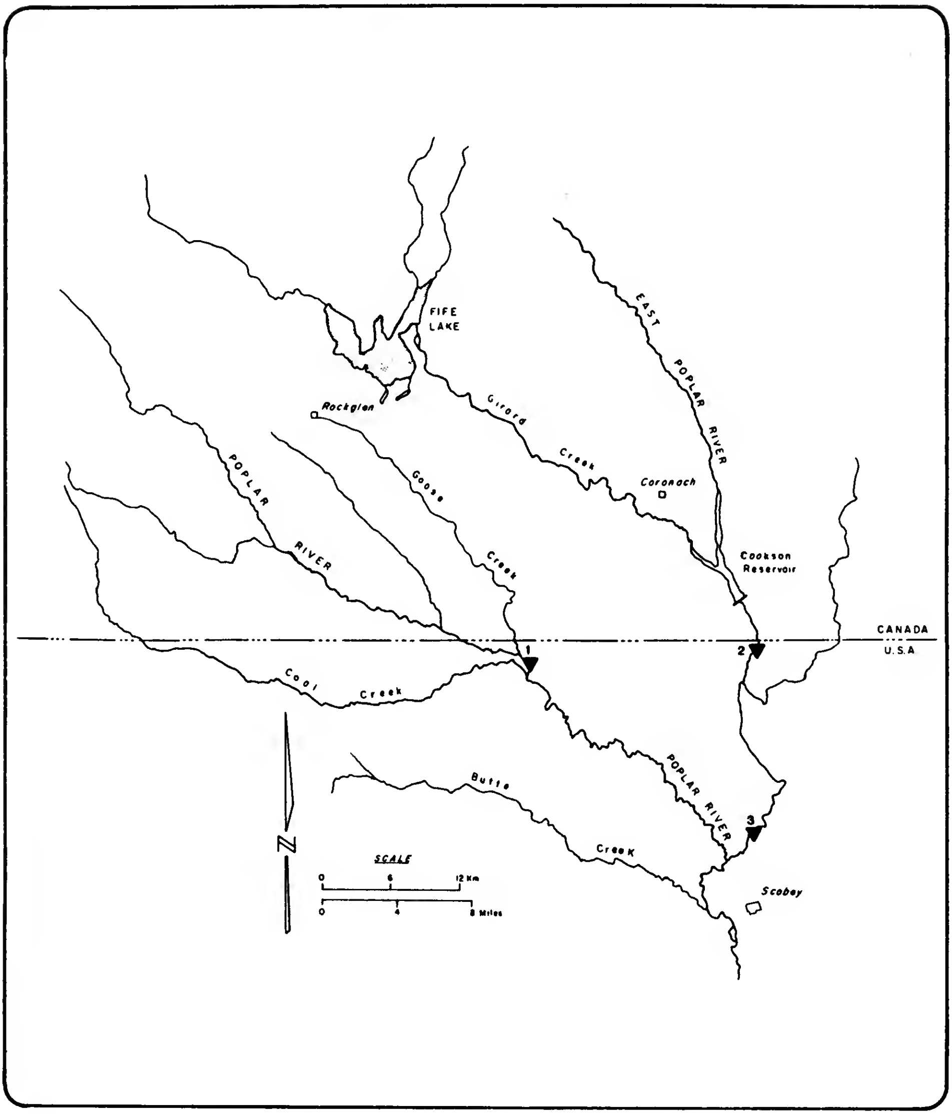
PARAMETERS

Watstore*			Sampling frequency no.		
Code	Parameter	Analytical Method	1	2	3
90410	Alkalinity - lab	Elect. Titration	BM	BM	BM
01106	Aluminum - diss	AE, DC Plasma	SA	SA	SA
00610	Ammonia - tot	Colorimetric	BM	BM	BM
00625	Ammonia +Org N-tot	Colorimetric	BM	BM	BM
01000	Arsenic - diss	AA, hydride	SA	SA	SA
01002	Arsenic - tot	AA, hydride	A	A	A
01010	Beryllium - diss	ICP	SA	SA	SA
01012	Beryllium - tot/rec	AA - Persulfate	A	A	A
01020	Boron - diss	AE, DC Plasma	BM	BM	BM
01025	Cadmium - diss	AA, GF	SA	SA	SA
01027	Cadmium - tot/rec	AA, GF - Persulfate	A	A	A
00915	Calcium	ICP	BM	BM	BM
00680	Carbon - tot Org	Wet Oxidation	SA	SA	SA
00940	Chloride - diss	Colorimetric	BM	BM	BM
01030	Chromium - diss	AE, DC Plasma	SA	SA	SA
01034	Chromium - tot/rec	AE, DC Plasma Persulfate	A	A	A
00080	Color	Electrometric, visual	BM	BM	BM
00095	Conductivity	Wheatstone Bridge	BM	D	BM
01040	Copper - diss	AA, GF	SA	SA	SA
01042	Copper - tot/rec	AA, GF - Persulfate	A	A	A
00061	Discharge - inst	Direct measur.	BM	BM	BM
00950	Fluoride	Electrometric	BM	BM	BM
01046	Iron - diss	AE, ICP	BM	BM	BM
01045	Iron - tot/rec	AA-Persulfate	A	A	A
01049	Lead - diss	AA, GF	SA	SA	SA
01051	Lead - tot/rec	AA, GF - Persulfate	A	A	A
00925	Magnesium - diss	AA	BM	BM	BM
01056	Manganese - diss	ICP	SA	SA	SA
01055	Manganese - tot/rec	AA-Persulfate	A	A	A
01065	Nickel - diss	AA, GF	SA	SA	SA
01067	Nickel - tot/rec	AA, GF - Persulfate	A	A	A
00615	Nitrite - tot	Colorimetric	BM	BM	BM
00630	Nitrate + Nitrite - tot	Colorimetric	BM	BM	BM
00300	Oxygen-diss	Winkler/meter	BM	BM	BM
70507	Phos, Ortho-tot	Colorimetric	BM	BM	BM
00400	pH	Electrometric	BM	BM	BM
00665	Phosphorous - tot	Colorimetric	BM	BM	BM
00935	Potassium - diss	AA	BM	BM	BM
00931	SAR	Calculated	BM	BM	BM
80154	Sediment - conc.	Filtration-Gravimetric	BM	BM	BM
80155	Sediment - load	Calculated	BM	BM	BM
01145	Selenium - diss	AA, hydride	SA	SA	SA
01147	Selenium tot	AA, hydride	A	A	A
00955	Silica	ICP	BM	BM	BM
00930	Sodium	ICP	BM	BM	BM
00945	Sulfate - diss	Turbimetry	BM	BM	BM
70301	Total Dissolved Solids	Calculated	BM	BM	BM
00010	Temp Water	Stem Therm.	BM	BM	BM
00020	Temp Air	Stem Therm.	BM	BM	BM
00076	Turbidity	Nephelometric	BM	BM	BM
80020	Uranium - diss	Spectrometry	-	MC	-
01090	Zinc - diss	ICP	SA	SA	SA
01092	Zinc - tot/rec	AA-Persulfate	A	A	A

* - Computer storage and retrieval system -- USGS

SYMBOLS: C - continuous; D - daily; M - monthly; BM - bimonthly; MC- monthly composite; A - annually at high flow; SA - semi-annually low and high flow; AA - atomic absorption; tot - total; rec - recoverable; diss - dissolved; AE - atomic absorption; DC - direct current; ICP - inductively coupled plasma; GF - graphite furnace

SURFACE WATER QUALITY MONITORING STATIONS (UNITED STATES)



Station Locations

Responsible Agency: Montana Bureau of Mines and Geology

Map Number	Well Location	Total Depth (a) (m)	Casing Diameter (cm)	Aquifer	Perforation Zone (m)
2*	37N47E17DABB	79	3.8 PVC	Hart Coal	76-79
3*	37N47E23AADD	36	3.8 PVC	Hart Coal	33-36
4*	37N48E23BBCC	104	3.8 PVC	Fox Hills - Hell Creek	102-104
5	37N47E1ABBB1	16	10.2 PVC	Alluvium	10-15
6	37N47E1ABBB2	25	10.2 PVC	Hart Coal	19-25
7	37N47E12BBBB	14	10.2 PVC	Hart Coal	39-45
8	37N47E13AADD	63	10.2 PVC	Alluvium	10-13
9	37N47E13ADAA01	13	10.2 PVC	Fort Union	16-62
10	37N48E5BABB	67	10.2 PVC	Alluvium-Coal	7-13
11	37N48E5AAAA	26	15.2 STEEL	Fox Hills - Hell Creek	65-67
12*	37N47E Sec 11 DDDD	62.5	5.08	Hart Coal	15-18
13*	37N47E Sec 3 CCCC	82.6	10.2	Hart Coal	56-59
14*	37N47E Sec 4 BBAB	89	10.2	Hart Coal	75-78
15	37N47E Sec 3 BBAA	26	10.2	Hart Coal	83-86
16	37N46E Sec 3 ABAB	88	10.2	Fort Union	24-25
17*	37N47E Sec 16 DDDD	90	10.6	Hart Coal	80-83
18*	37N46E Sec 1 BBBA	59	10.2	Hart Coal	80-82
19	37N47E Sec 15 AAAB	22	10.2	Hart Coal	54-56
20*	37N47E Sec 24 CCCC	106	5.08	Hart Coal	19-22
21*	37N47E Sec 6 DBAA	21	10.2	Hart Coal	100-103
22*	37N47E Sec 9 CBCC		10.2	Fort Union	18-21

Parameters

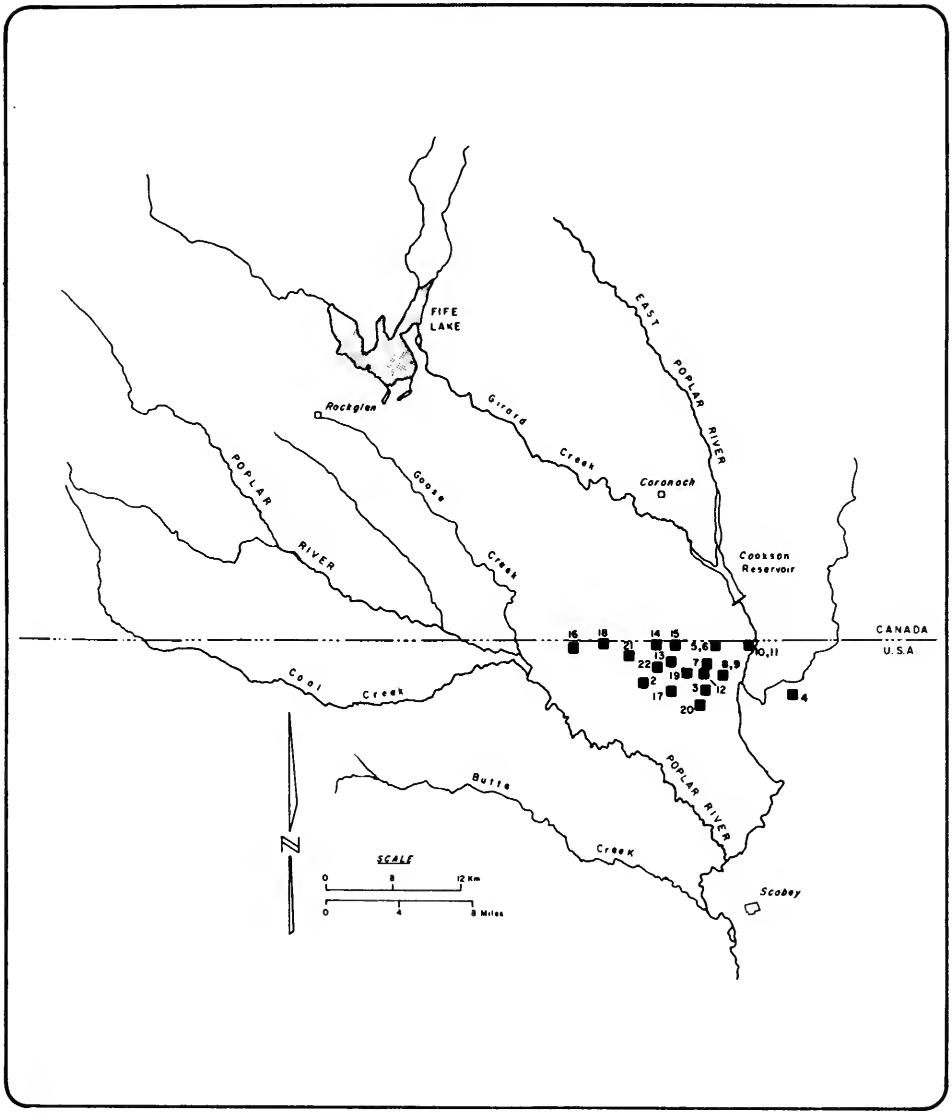
Storet ** Code	Parameter	Analytical Method	Sampling Frequency Station No.
00440	Bicarbonates	Electrometric Titration	Sample collection is annually for all active stations.
01020	Boron-diss	Emission Plasma, ICP	
00915	Calcium	Emission Plasma	
00445	Caronates	Electrometric Titration	
00940	Chloride	Ion Chromatography	The analytical method descriptions are those of the Montana Bureau of Mines and Geology Laboratory where the samples are analyzed.
00095	Conductivity	Wheatstone Bridge	
01040	Copper-diss	Emission Plasma, ICP	
00950	Fluoride	Ion Chromatography	
01046	Iron-diss	Emission Plasma, ICP	
01049	Lead-diss	Emission Plasma, ICP	
01130	Lithium-diss	Emission Plasma, ICP	
00925	Magesium	Emission Plasma, ICP	
01056	Manganese-diss	Emission Plasma, ICP	
01060	Molybdenum	Emission Plasma, ICP	
00630	Nitrate	lon Chromatography	
00400	pH	Eletrometric	
00935	Potassium	Emission Plasma, ICP	
01145	Selenium-diss	AA	
00955	Silica	Emission Plasma, ICP	
00930	Sodium	Emission Plasma, ICP	
01080	Strontium-diss	Emission Plasma, ICP	
00445	Sulphate	Ion Chromatography	
00190	Zinc-diss	Emission Plasma, ICP	
70301	TDS	Calculated	

* - Inactive as of 1989
** - Computer storate and retrieval system -- USGS

SYMBOLS

AA - Atomic Absorption; ICP - Inductively Coupled Plasma Unit

GROUND WATER QUALITY MONITORING (UNITED STATES)

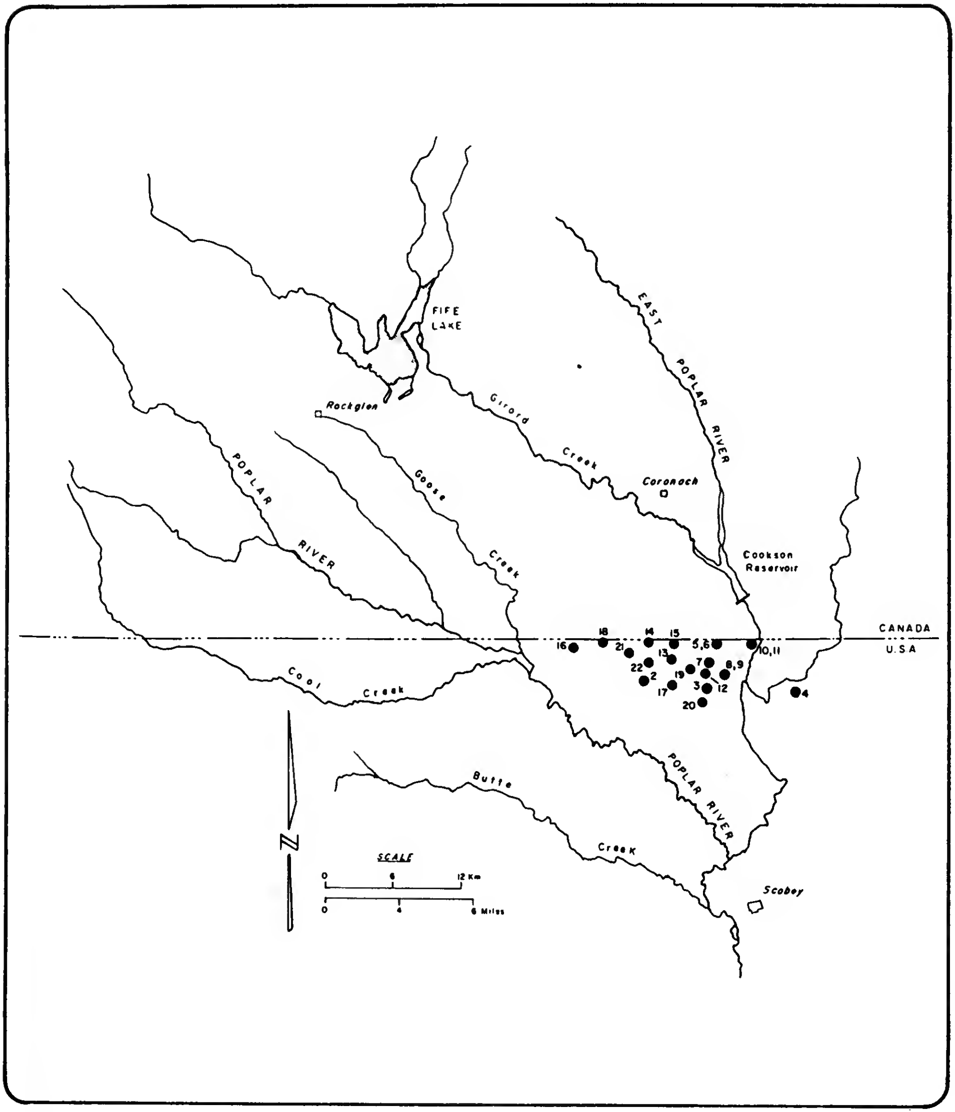


GROUND WATER LEVELS TO MONITOR POTENTIAL DRAWDOWN
DUE TO COAL SEAM DEWATERING

Responsible Agency: Montana Bureau of Mines and Geology

No. on Map	Sampling
2 to 22	Determine water levels quarterly

GROUNDWATER PIEZOMETERS TO MONITOR POTENTIAL DRAWDOWN DUE TO COAL SEAM DEWATERING



ANNEX 3

REPORTS REVIEWED DURING 1990

BY THE POPLAR RIVER BILATERAL MONITORING COMMITTEE

REPORTS REVIEWED DURING 1990

BY THE POPLAR RIVER BILATERAL MONITORING COMMITTEE

Clifton Associates, 1990, Poplar River Power Station; Hydrogeological evaluation, ash storage lagoon, Coronach, Saskatchewan, Sask Power, File AD 18.14.1, 89 p.

Clifton Associates, 1990, Poplar River Power Station; Ash Stacking Study, Coronach, Saskatchewan, Sask Power, File: AD 18.14., 35 p.

Schmidt, Fred and Sholes, Brenda, 1990, final report; Poplar River Monitoring: Montana Bureau of Mines and Geology, Open-File Report No. 226, 164 p.

ANNEX 4

RECOMMENDED FLOW APPORTIONMENT

IN THE POPLAR RIVER BASIN

BY THE INTERNATIONAL SOURIS-RED RIVERS ENGINEERING BOARD,

POPLAR RIVER TASK FORCE (1976)

* RECOMMENDED FLOW APPORTIONMENT IN THE POPLAR RIVER BASIN

The aggregate natural flow of all streams and tributaries in the Poplar River Basin crossing the International Boundary shall be divided equally between Canada and the United States subject to the following conditions:

1. The total natural flow of the West Fork Poplar River and all its tributaries crossing the International Boundary shall be divided equally between Canada and the United States but the flow at the International Boundary in each tributary shall not be depleted by more than 60 percent of its natural flow.

2. The total natural flow of all remaining streams and tributaries in the Poplar River Basin crossing the International Boundary shall be divided equally between Canada and the United States. Specific conditions of this division are as follows:

   (a) Canada shall deliver to the United States a minimum of 60 percent of the natural flow of the Middle Fork Poplar River at the International Boundary, as determined below the confluence of Goose Creek and Middle Fork.

   (b) The delivery of water from Canada to the United States on the East Poplar River shall be determined on or about the first day of June of each year as follows:

      (i) When the total natural flow of the Middle Fork Poplar River, as determined below the confluence of Goose Creek, during the immediately preceding March 1st to May 31st period does not exceed 4,690 cubic decameters (3,800 acre-feet), then a continuous minimum flow of 0.028 cubic metres per second (1.0 cubic feet per second) shall be delivered to the United States on the East Poplar River at the International Boundary throughout the succeeding 12 month period commencing June 1st. In addition, a volume of 370 cubic decameters (300 acre-feet) shall be delivered to the United States upon demand at any time during the 12 month period commencing June 1st.

      (ii) When the total natural flow of the Middle Fork Poplar River, as determined below the confluence of Goose Creek, during the immediately preceding March 1st to May 31st period is greater than 4,690 cubic decameters (3,800 acre-feet), but does not exceed 9,250 cubic decameters (7,500 acre-feet), then a continuous minimum flow of 0.057 cubic metres per second (2.0 cubic feet per second) shall be delivered to the United States on the East Poplar River at the International Boundary during the succeeding period June 1st through August 31st. A minimum delivery of 0.028 cubic metres per second (1.0 cubic feet per second) shall then be maintained from September 1st through to May 31st of the following year. In addition, a volume of 617 cubic decameters (500 acre-feet) shall be delivered to the United States upon demand at any time during the 12-month period commencing June 1st.

* Canada-United States, 1976, Joint studies for flow apportionment, Poplar River Basin, Montana-Saskatchewan: Main Report, International Souris-Red Rivers Board, Poplar River Task Force, 43 pp.

(iii) When the total natural flow of the Middle Fork Poplar River, as determined below the confluence of Goose Creek, during the immediately preceding March 1st to May 31st period is greater than 9,250 cubic decameters (7,500 acre-feet), but does not exceed 14,800 cubic decameters (12,000 acre-feet), then a continuous minimum flow of 0.085 cubic metres per second (3.0 cubic feet per second) shall be delivered to the United States on the East Poplar River at the International Boundary during the succeeding period June 1st through August 31st. A minimum delivery of 0.057 cubic metres per second (2.0 cubic feet per second) shall then be maintained from September 1st through to May 31st of the following year. In addition, a volume of 617 cubic decameters (500 acre-feet) shall be delivered to the United States upon demand at any time during the 12 month period commencing June 1st.

(iv) When the total natural flow of the Middle Fork Poplar, as determined below the confluence of Goose Creek, during the immediately preceding March 1st to May 31st period exceeds 14,800 cubic decameters (12,000 acres-feet) then a continuous minimum flow of 0.085 cubic metres per second (3.0 cubic feet per second) shall be delivered to the United States on the East Poplar River at the International Boundary during the succeeding period June 1st through August 31st. A minimum delivery of 0.057 cubic metres per second (2.0 cubic feet per second) shall then be maintained from September 1st through to May 31st of the following year. In addition, a volume of 1,230 cubic decameters (1,000 acre-feet) shall be delivered to the United States upon demand at any time during the 12-month period commencing June 1st.

(c) The natural flow at the International Boundary in each of the remaining individual tributaries shall not be depleted by more than 60 percent of its natural flow.

3. The natural flow and division periods for apportionment purposes shall be determined, unless otherwise specified, for periods of time commensurate with the uses and requirements of both countries.

ANNEX 5

METRIC CONVERSIONS

ac	=	4,047 m^3 = 0.04047 ha
ac-ft	=	1,233.5 m^3 = 1.2335 dam^3
Cx	=	1.8 Fx
cm	=	0.3937 in.
cm^2	=	0.155 in^2
dam^3	=	1,000 m^3 = 0.8107 ac-ft
ft^3	=	28.3171 x 10-3m^3
ha	=	10,000 m^2 = 2.471 ac
hm	=	100 m = 328.08 ft
hm^3	=	1 x 106 m^3
I.gpm	=	0.0758 L/s
in	=	2.54 cm
kg	=	2.20462 lb = 1.1 x 10-3 tons
km	=	0.62137 miles
km^2	=	0.3861 mi^2
L	=	0.3532 ft^3 = 0.21997 I. gal = 0.26420 U.S. gal
L/s	=	0.035 cfs = 13.193 I.gpm = 15.848 U.S. gpm
m	=	3.2808 ftm^2 = 10.7636 ft^2
m^3	=	1,000 L = 35.3144 ft^3 = 219.97 I. gal = 264.2 U.S. gal
m^3/s	=	35.314 cfs
mm	=	0.00328 ft
tonne	=	1,000 kg = 1.1023 ton (short)
U.S. gpm	=	0.0631 L/s

<u>For Air Samples</u>

ppm = 100 pphm = 1000 x (Molecular Weight of substance/24.45) mg/m390